ANNUAL REPORT

OF THE

WATER-SUPPLY DEPARTMENT,

FOR THE YEAR 1893.

BOSTON:
ROCKWELL AND CHURCHILL, CITY PRINTERS.
1894.

DAM VI. — SHOWING WATER SIDE.

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Office of the Boston Water Board,
City Hall, Boston, February 1, 1894.

Hon. Nathan Matthews, Jr.,
Mayor of the City of Boston:

Sir: The Boston Water Board, in charge of the Water-Supply Department, herewith submit their annual report for the financial year ending January 31, 1894.

The disbursements by the department for the year were as follows:

Money expenditures, Cochituate Water-Works (see page 20)	$895,652 19
Money expenditures, Mystic Water-Works (see page 21)	149,678 79
	$1,045,330 98
Less increase in stock during year (see page 22)	16,492 61
	$1,028,838 37

Current expenses, Cochituate Water-Works	$393,154 00	
Current expenses, Mystic Water-Works	151,579 90	
Extension of mains, etc. . . .	256,193 57	
Additional supply of water .	190,655 62	
High service	37,255 28	
		$1,028,838 37

EARNINGS AND EXPENDITURES.

The total receipts of the Cochituate Water-Works, from all sources, for the year ending January 31, 1894, were as follows, viz.:

Balance of revenue from 1892–93		$15,820 46
Income from sales of water	$1,637,531 94	
Income from shutting off and letting on water, and fees	3,088 44	
Elevator, fire and service pipes, sale of old materials, etc.	36,917 60	
		1,677,537 98
		$1,693,358 44

The total expenditures of the Cochituate Water-Works from revenue, for the year ending January 31, 1894, were as follows, viz.:

Current expenses, viz.:			
Water-Supply Department	$393,154 00		
Less stock used purchased in previous years	10,224 68		
	$382,929 32		
Water-Income Department	50,478 86		
		$433,408 18	
Interest on funded debt		826,077 88	
Sinking-fund requirement, 1892–93		229,520 00	
Refunded water-rates		1,479 18	
Extension of mains, etc.		132,925 93	
Balance to Cochituate Water Sinking-Fund		69,947 27	
			$1,693,358 44

The total receipts of the Mystic Water-Works from all sources, for the year ending January 31, 1894, were as follows, viz.:

Income from sales of water	$421,574 18	
Income from shutting off and letting on water, and fees	984 40	
Service-pipes, repairs, etc.	1,204 02	
Sale of portion of Mystic sewer to State of Massachusetts	52,637 00	
		$476,399 60

The total expenditures of the Mystic Water-Works from revenue, for the year ending January 31, 1894, were as follows, viz.:

Current expenses, viz.:		
Water-Supply Department	$151,579 90	
Less stock used, paid for in previous years	1,901 11	
	$149,678 79	
Water-Income Department	10,965 18	
	$160,643 97	
Interest on funded debt	18,707 59	
Refunded water-rates	151 42	
Amount paid Chelsea, Somerville, and Everett, under contracts	144,101 35	
Extension of mains, etc., Cochituate Department	152,795 27	
		$476,399 60

For further details of the expenditures, the condition of the water debts, and the outstanding loans, we refer to the tables appended.

CONSUMPTION OF WATER, RAINFALL, ETC.

The daily average consumption during the past year was 47,453,200 gallons on the Cochituate and Sudbury, and 10,742,500 gallons on the Mystic, or 58,195,700 gallons on the combined supplies, being an increase of 13.8 per cent. over the previous year. The consumption per capita was 102.4 gallons, being larger than any year since the works were built.

Although the rainfall was above the average of the last twenty years, it was so unequally distributed that the amount of water stored was reduced to the smallest quantity since the Sudbury works have been in use.

In the month of October the water had fallen to such an extent that it was deemed advisable to procure pumps and put them in readiness for pumping water into the conduit at Lake Cochituate. Notices were issued to the water-takers through the newspapers to economize in the use of water, and all possible means were taken to prevent waste. Fortunately, however, the drought was broken by the late fall rains, and pumping was not resorted to on the Cochituate supply. The pumps on the Mystic supply were put in condition, and water was pumped from the Mystic lake into the

conduit from October 19th until November 4th, at which time the water had risen to such a point that further use of the pumps was unnecessary. On October 23d the water in Mystic lake reached its lowest point, 8.90 feet below high water, which was within 1.27 feet of the lowest point ever reached. After November 4th the water rose steadily, and on January 19th it again wasted over the dam.

EXTENSION OF MAINS.

The work of extending mains has been somewhat less than for the previous year, for the reason that we were obliged to curtail in the expenditures, and only such work as was absolutely necessary was done. Some two miles less of main pipe was laid than during the previous year.

The total number of miles of pipe now connected with the Cochituate works is 560.06. Payment was made to the Park Department for the Jamaica pond aqueduct pipe system, consisting of about ten miles of pipe, amounting to \$75,199.70, which amount, together with \$29,527.63 for stock purchased but not used, deducted from the total amount expended, leaves \$180,993.87 for the actual cost of extensions during the year, being about \$40,000 less than for the previous year.

The whole cost of extension of mains during the year has been paid from the surplus revenue.

We are required to expend quite a large amount of money each year for extensions of pipe in advance of its actual need in new streets which are continually being laid out under the provisions of chapter 323, sections 10 and 12, of the Acts of 1891; but on all petitions for extensions we require a guarantee of 5 per cent. for five years on the cost. Owing to the changing and extensions of Commonwealth avenue the large mains were raised, relaid, and extended during the winter, thereby enabling us to keep quite a large force of men employed that otherwise would have had to be suspended.

The abolishment of the grade crossing at the Old Colony Railroad at Dover street has necessitated a large amount of work in order to protect the pipes crossing Dover-street bridge and in changing the line to conform to the new grade. This work is not yet completed.

We have in contemplation other important work, such as the laying of a second force main (36 inches) from the Chestnut Hill to the Fisher Hill reservoir, a new main to South Boston *via* Swett street, and the changing and en-

larging of the main from Charlestown to Chelsea to conform to the changes on account of the abolishment of the grade crossing of the Boston & Maine Railroad.

HARBOR SERVICE.

The submerged pipes supplying water to the several islands in Boston harbor are a constant source of trouble and annoyance to this department, and great expense is incurred each year in keeping them in repair. Their liability to freeze in exposed places at low tide, as well as the disturbance caused by the strong currents in the channels, make it impossible to ensure an unfailing supply of water to the islands, and we deem it most essential that storage reservoirs be constructed on all the islands, of sufficient capacity to supply their needs, both for domestic and fire purposes, in cases of emergency.

The cost of extensions and repairs of the water-works system from Neponset to Moon, Thompson's, Long, Rainsford, and Gallop's islands to February 1, 1894, is as follows:

Siphon across Neponset river	$8,000 00
Main from Neponset to end of Moon island,	19,741 93
Lillie V. Titus, right of way in Squantum,	3,500 00
Flexible pipe between Moon and Long islands	9,903 50
Main from Long island shore to almshouse,	4,986 28
Extension to Rainsford island	3,233 41
Extension to Gallop's island	3,248 64
Extension to Thompson's island . . .	9,965 29
Extension of high service to entire system .	3,445 88
	$66,024 93
Repairs on the entire line	6,608 68
Total cost to February 1, 1894 . . .	$72,633 61

In addition to the above the Board of Health expended some $1,300 for a temporary pipe between Long and Gallop's islands.

The Board have requested the Engineer to devise and report some plan, if possible, whereby the harbor system can be maintained without such extraordinary expense. Previous to September, 1893, the harbor system was supplied from the low service, but on the 12th of that month the Board ordered the high service to be connected.

During the past year the supply has been extended to Fort Warren, the pipe to that point being laid by the United States Government.

FIRE SERVICE.

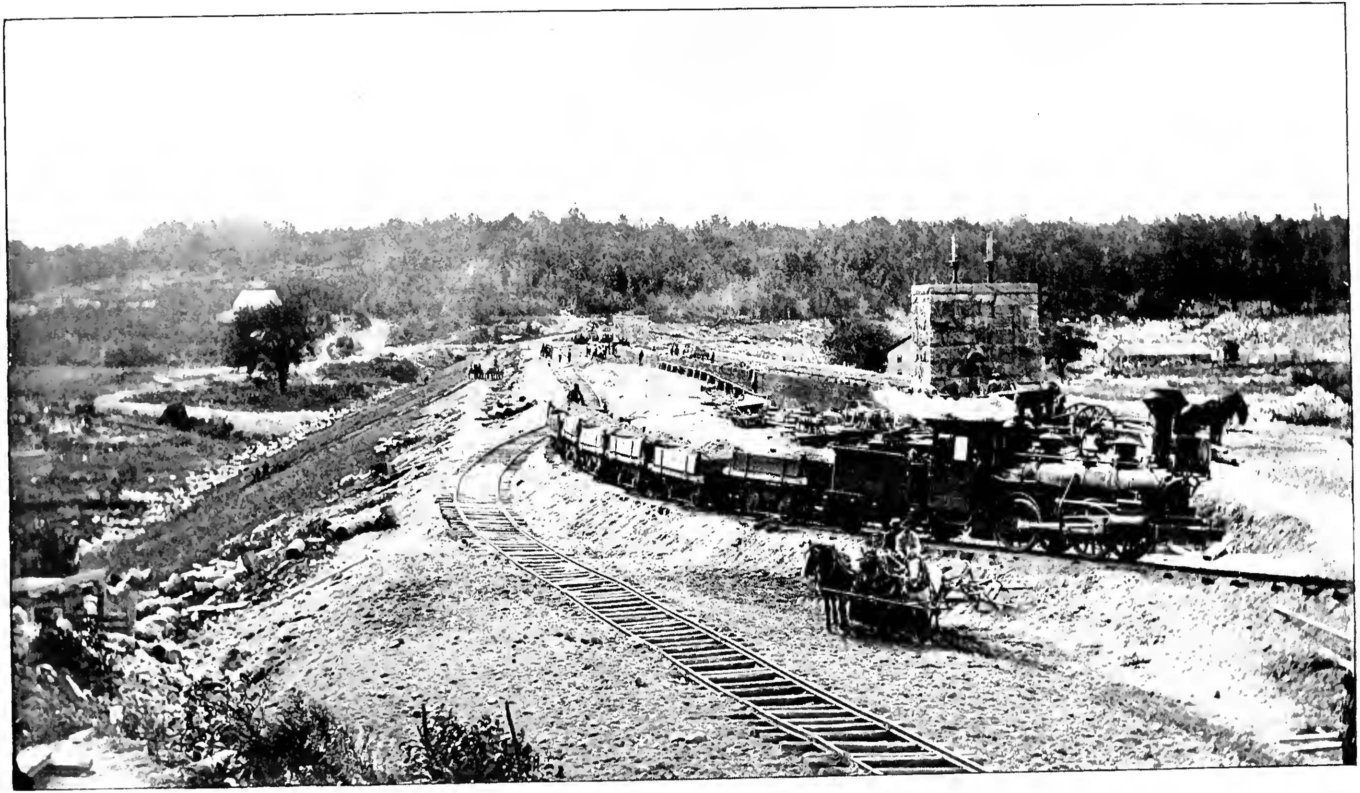
Owing to the many petitions received by the Board for connections with the high service to supply automatic sprinklers and fire pipes now so generally in use throughout the business district of the city, the Board, after several conferences with the Board of Fire Underwriters, and many of the merchants and owners of buildings, have practically decided to equip the business district with a duplicate set of pipes to be connected with the high service, and be used exclusively for fire protection in supplying water for fire pipes, automatic sprinklers, and roof hydrants, the regular street hydrants to be retained on the low service, so that in case of a large conflagration, if the fire pipes entering the buildings become broken by falling walls or otherwise, thereby greatly reducing the head of water, the supply for the fire-engines from the street hydrants would not be impaired.

In order to determine as to the necessity for larger mains in the streets, the Board have established recording gauges in a number of the fire-engine houses in the various districts of the city for the purpose of keeping a continuous record of pressures at different points, arrangements having been made with the Board of Fire Commissioners to have the gauges properly looked after by their men.

HIGH-SERVICE PUMPING-ENGINE.

The new 20,000,000 gallons per day high-service pumping-engine contracted for with N. F. Palmer, Jr., & Co., of New York, for the Chestnut Hill Pumping-Station is now built and set up in the shops of the Quintard Iron Works. It will be taken down and brought to this city immediately, and we hope to have it in operation by July 1st. When fully completed, it is safe to say that this will be the best pumping-engine in the United States.

In connection with this engine and pump a steel boiler of the Belpaire Fire-Box pattern is now in process of construction at the Atlantic Works, East Boston. The boiler will probably be in position by June 1st. All of this machinery is being made from plans and specifications prepared by Mr. E. D. Leavitt, with every improvement that science has suggested.



DAM VI. — SHOWING DOWN STREAM SIDE.

The saving in coal with this plant will be at least $33\frac{1}{3}$ per cent.

BASIN 6.

The work on this Basin has been carried on vigorously during the year, and it is now practically completed and gradually being filled with water, the gates having been closed early in January.

Considerable work yet remains to be done, however, to put the basin in a finished condition, but the Board hope to be able to complete the work thoroughly with the balance of the appropriation on hand.

The total cost of this basin, including the dam, to February 1st, is $866,575.65. Its capacity is about the same as that of Basin No. 4, — 1,400,000,000 gallons. This will add 4,500,000 gallons to the daily capacity of the supply.

WHITEHALL POND CASES.

Preparations were made in the year 1892 for the trial of these cases, which finally took place early in 1893 before a commission appointed by the Superior Court, consisting of Messrs. Chas. H. Allen, Frederic T. Greenhalge, and Sigourney Butler. These cases were actions for damages brought by the Dwight Printing Company, represented by Eben D. Jordan, owning a two-thirds interest in Whitehall pond, and the Wood Brothers and Newhall, owning the other one-third. The questions involved were of an intricate character, and the greater part of the year passed before the commissioners made their award. Several experts were employed to represent the interests of the city. The cases still remain unsettled at the date of this report.

BASIN 5.

By an order of the City Council approved April 26, 1893, the further sum of $2,500,000 was appropriated to extend and perfect the water-supply in accordance with the order of November 13, 1889, and all other statutes, ordinances, and orders relating to the acquisition of land and construction of basins and reservoirs upon the Sudbury river water-shed, and on May 16th the Engineer was requested to prepare plans and specifications for the construction of a new dam for Basin No. 5 on Stony brook in the town of Southborough and the city of Marlborough.

As the construction of this basin necessitated the changing of certain roads in Southborough, numerous conferences have been held with the County Commissioners of Worcester County, and also with a Committee of Citizens from

Southborough, with whom arrangements have practically been made. On July 10th the Board requested the Law Department to prepare the papers necessary to enable the city to take the lands required for this basin, but owing to some changes in the plans the taking has been delayed. A contract for building the dam was awarded to Moulton & O'Mahoney on July 25th, and the work will be commenced as soon as the taking of lands is made. When completed this basin will be the largest of the series, and will have a capacity of 7,438,000,000 gallons and will cover about 1,500 acres, adding at least 12,000,000 gallons to the daily supply in the driest year.

AREA AND COST OF BASINS.

The following table shows the area in acres and storage capacity of each of the basins already constructed on the Sudbury supply, also the cost of each basin:

	Area H. W.	Area Not Flowed.	Total Area Land.	Storage in Million Gals.	Daily Supply Proportional to Capacity, Million Gals.
Basin 1......	143	64	207	280	1.
" 2	134	50	184	530	1.8
" 3......	253	90	343	1,080	3.7
" 4	167	94	261	1,400	4.9
" 6......	185	270	455	1,530	5.2

	Dam.	Basin.	Land Damages.	Total Cost.
Basin 1	$144,929 15	$44,455 20	$67,759 46	$257,143 81
" 2......	152,982 51	147,957 82	165,013 78	465,954 11
" 3......	194,950 13	183,939 98	40,512 61	419,402 72
" 4.... ..	521,998 45	265,517 93	26,330 00	813,846 38
* " 6......	512,636 48	327,062 58	26,876 59	866,575 65

* Construction account not yet closed.

FUTURE SUPPLY.

In the last two reports attention has been called to the subject of a future supply for Boston. From the best data now at hand the entire development of the Sudbury supply will only be sufficient to supply Boston for about eight years. The growth of the city is keeping abreast of this development, indeed during the latter part of the fall and early winter the basins were lower than ever, and much anxiety was felt by the Board lest they should be compelled to curtail in the use of water. The Legislature of 1892 appropriated a sum of money for the State Board of Health to make some studies looking to a supply sufficient to provide for Boston and surrounding cities and towns, or in other words a Metropolitan system, and with this end in view the State Board have been making soundings and collecting data on the Nashua river above Clinton, and there is no doubt that if this source of supply should be adopted a sufficient quantity of good water could be procured to supply all the communities within a radius of ten miles of the State House for many years to come. This water could pass through the new basin No. 5, which is about to be constructed.

MYSTIC DEPARTMENT.

The Mystic works have received the usual care and attention during the year and are generally in good condition.

Early in the year a committee from the town of Winchester presented to the Board a proposition and plan to take a tract of about twenty acres of land located in the central part of that town to remove the nuisance therefrom and dedicate it to the public for a park. The plan contemplates the removal of an old tannery which has for years endangered the purity of the water-supply. After an examination of the plans, and consideration of the advantages which the city would derive from the scheme as an improvement to the Mystic supply, the Board requested the Engineer to investigate and report the approximate cost of the land along the Abajona river included in the scheme which it would be desirable for the city to take for the protection of its water-supply. Numerous conferences were held with the committee, but up to the closing of this report nothing has been done on the part of the city towards acquiring any of the land.

By request of the authorities of Medford a connection of their system with the Mystic works has been made at Boston avenue near the reservoir, for use only in cases of emergency.

On July 12, 1893, the Board engaged Mr. E. D. Leavitt, Mechanical Engineer, to furnish a design and specifications for a 10,000,000-gallon per diem pumping-engine for the Mystic Station, and on December 26, 1893, the contract for building and erecting the engine was awarded to the George F. Blake Manufacturing Company, for $38,950, — the work to be completed within nine months from the date of execution of the contract.

On July 14, 1893, the Metropolitan Sewerage Commissioners in behalf of the Commonwealth of Massachusetts took, by right of eminent domain, a portion of the Mystic sewer in Woburn, in connection with the North Metropolitan sewer system, for which the State paid to the city of Boston the sum of $52,637.

The Cochituate high service was turned on to supply the residents on the top of Bunker Hill, on June 26, the Mystic supply being inadequate to furnish an ample supply at that elevation.

During the month of November, the water in Mystic lake being extremely low, it was considered a favorable time to improve the shallow portion at the upper end of the lake, and a large temporary force was employed until the rise in the water necessitated the suspension of the work, some 14,000 cubic yards of soil being removed.

ELECTROLYSIS.

In 1892 the attention of the Board was drawn to the fact that the lead service-pipes in the immediate vicinity of the power-station of the West End Railroad Company were being destroyed from some cause, and from the best information which we could obtain it seemed probable that the destructive action was due to the underground currents of electricity.

The subject was at once placed in the hands of the City Engineer for investigation, and the detailed results of the partial study which has been made under his direction by Messrs. Stone and Webster will be found in the City Engineer's report.

Many other cities throughout the country are experiencing the same difficulty, and as it is a subject of great importance we propose to continue the investigation with the purpose of finding the best means of preventing the corrosion which, although slow in its action, is nevertheless sure in time to cause serious trouble to our pipe system.

TAXATION OF PROPERTY.

The following act relating to the taxation of property held for purposes of a water-supply was passed by the Legislature in 1893:

AN ACT RELATING TO PROPERTY HELD FOR THE PURPOSE OF A WATER SUPPLY.

Be it enacted etc., as follows:

SECTION 1. Any city or town holding property, taken by purchase or otherwise, for the purposes of its water supply, whether for domestic, manufacturing, or other purposes, in another city or town, shall not pay any tax on such property, but shall hereafter in the month of September annually pay to such other city or town for each lot of land held therein for said purposes, an amount of money equal to the rate of taxation per thousand dollars in such other city or town, for every one thousand dollars of the average of the assessed valuations of the land, without buildings or other structures, for the three years next preceding the taking thereof, the said assessed valuation for each year being first reduced by the amount of all abatements allowed thereon: *provided, however*, that any land or building from which any revenue in the nature of rent is received from any person occupying or using the same shall be subject to taxation.

SECT. 2. The assessors of any city or town in which land is held for the aforesaid purposes on the day of the passage of this act shall, within one year after such passage, determine the aforesaid average valuation of such land and certify the same to the mayor of the city or the selectmen of the town holding the same; and the assessors of any city or town in which any land is hereafter taken for the aforesaid purposes shall, within one year after such taking, determine and certify as aforesaid the said average valuation of the land so taken. In determining said average valuation the aforesaid assessed valuation for each lot of such land shall be taken to be the proportional part of the assessed valuation of the estate of which such lot formed a part, which the value of the land thereof, exclusive of buildings and other structures, bore in the year of assessment to the entire value of said estate.

SECT. 3. If the aforesaid mayor of the city or selectmen of the town be dissatisfied with said determination, the said average valuation of such land shall be determined in the manner provided in the preceding section by the superior court for the county in which such land is situated on appeal of such mayor or selectmen from said determination, filed with the clerk of said court within six months after receiving the aforesaid notice thereof, and the provisions of sections two and four of chapter one hundred and twenty-seven of the acts of the year eighteen hundred and ninety, except as is otherwise provided herein, shall apply to appeals under this act.

SECT. 4. This act shall take effect upon its passage. [*Approved May 12, 1893.*]

In accordance with the provisions of this act the Board have had lists made of all the taxable property and the valuations for the three years previous to the dates of the taking of lands in Framingham and Ashland, and these towns have also prepared their lists. The lists have been agreed upon so far as these two towns are concerned, but none of the

other towns have yet furnished their statements as required by the law.

FILTRATION.

The Board have been endeavoring for several years in one way or another to purify Pegan brook in Natick, and they feel that they have been moderately successful in getting rid of all the sources of pollution flowing directly into the stream ; but there is always danger in such a situation, and they have tried to persuade Natick to adopt a system of sewerage, and have offered to contribute to any well-devised plan. Unnecessary delays, however, in these negotiations have occurred. Feeling that it would be unwise to postpone this work any longer, the Board, a year ago, determined to take the matter in hand and put in a system of filter beds on Pegan brook. A piece of land adapted to this purpose was secured early in the season, and three large natural beds were built, into which the water flowing in the brook is pumped. After passing through several feet of sand the water enters the lake.

The Board have also secured a piece of land at the head of Basin 5, in Marlborough, and intend to build filter basins modelled after those at Natick. These beds will be used to filter the water flowing through Marlborough, and which otherwise would discharge into the new basin whenever it is built.

BIOLOGICAL LABORATORY.

The laboratory established at Chestnut Hill Reservoir has proved its value in aiding us to form an opinion as to the character of the water in the several sources of supply from week to week. It has now become an established portion of the work.

IN GENERAL.

Early in the spring the Board employed J. N. McClintock to prepare a model in relief about 6 feet × 8 feet, and colored, showing the Cochituate and Sudbury water-sheds, with the lakes, ponds, and basins connected with Boston's water-supply. This model, together with a number of large photographs, was exhibited at the World's Columbian Exposition in Chicago. Since the close of the Fair the Board have received from the Executive Committee on Awards an official copy of the award made by them, viz., "For careful and skilful preparation and instructive display," which will be inscribed in the diploma and forwarded to the Board in due time.

GENERAL STATISTICS.

Sudbury and Cochituate Works.	1891.	1892.	1893.
Daily average consumption in gallons	37,686,980	41,312,400	47,453,200
Daily average consumption in gallons per inhabitant	89.3	95.3	107.5
Daily average amount used through meters, gallons	10,186,400	11,225,900	11,651,600
Percentage of total consumption metered	27.0	27.2	24.5
Number of services	62,877	65,074	66,586
Number of meters and motors	4,357	4,412	4,585
Length of supply and distributing mains, in miles	519	536	560
Number of fire-hydrants in use	5,643	5,793	6,042
Yearly revenue from water-rates	* $1,838,494 30	$1,433,413 78	$1,637,531 94
Yearly revenue from metered water	† $606,451 00	$649,672 31	$683,948 52
Percentage of total revenue from metered water	33	45.3	41.8
Cost of works on Feb. 1, 1892, 1893, and 1894	* $21,643,526 91	$22,243,351 56	$22,727,456 03
Yearly expense of maintenance	* $398,755 92	$350,743 68	$393,154 00
Mystic Works.			
Daily average consumption in gallons	9,055,200	9,810,800	10,742,500
Daily average consumption in gallons per inhabitant	74.7	78.6	84.4
Daily average amount used through meters, gallons	1,845,500	1,862,200	1,921,570
Percentage of total consumption metered	20.4	19	17.9
Number of services	20,566	21,588	22,398
Number of meters and motors	427	550	482
Length of supply and distributing mains, in miles	158	160	165
Number of fire-hydrants in use	1,116	1,223	1,306
Yearly revenue from water-rates	* $406,784 26	$394,008 75	$421,573 48
Yearly revenue from metered water	† $102,719 26	$105,685 56	$109,367 37
Percentage of total revenue from metered water	25.2	26.8	25.9
Cost of works on Feb. 1, 1892, 1893, and 1894	$1,710,943 70	$1,713,227 00	$1,721,609 33
Yearly expense of maintenance	* $174,421 92	$117,922 20	$147,417 10

* Thirteen months. † Twelve months.

On July 18, 1893, Commissioner Robert Grant resigned his position on the Board to accept the position of Associate Justice of the Probate Court, he having served continuously since April, 1888.

On December 13, 1893, Thaddeus C. Dunn, chief engineer at the Chestnut Hill Pumping-Station, died, after a lingering illness, having served the city faithfully for the past twenty-four years, and the Board appointed Mr. E. C. Norris to fill the vacancy.

The employees of this department generously contributed to the fund for the relief of the needy unemployed citizens to the amount of $1,253.33, the secretary forwarding a check for that amount to the treasurer of the Citizens' Relief Committee on January 6th.

We annex hereto detailed statements of the expenditures, etc., also reports of the Superintendents of the several divisions and the City Engineer.

Respectfully submitted,

THOMAS F. DOHERTY,
JOHN W. LEIGHTON,
WILLIAM S. MCNARY,
Boston Water Board.

MAINTENANCE ACCOUNTS, COCHITUATE WATER-WORKS.

(FROM REVENUE.)

FEBRUARY DRAFT, 1893, TO FEBRUARY DRAFT, 1894.

Boston Water Board:		
Salaries of two Commissioners, Chief Clerk and Secretary, Executive Clerk, Purchasing Agent, Asst. Clerk, Messenger, and Special Agent,	$16,537 85	
Travelling expenses	2,104 54	
Printing and stationery . . .	876 16	
Advertising, postage, and miscellaneous	3,590 26	
		$23,108 81
Eastern Division:		
Salaries of Superintendents, Clerks, and Foremen	$16,491 84	
Travelling expenses and transportation of men	1,000 00	
Printing and stationery . . .	922 60	
Miscellaneous	142 85	
		18,557 29
Western Division:		
Salaries of Superintendent, Assistant Superintendent, and Clerks . .	$25,007 03	
Travelling expenses	885 98	
Printing and stationery . . .	394 15	
Miscellaneous	174 00	
		26,461 16
Engineering		8,162 73
New meters, and setting		8,336 90
Meters, repairing		20,332 93
Machine-shop, Albany street		12,381 23
Telephones		1,560 48
Cochituate Aqueduct		1,618 34
Sudbury Aqueduct		5,521 74
Main-pipe relaying (including stock and labor) .		10,689 69
" repairing " " " " .		19,426 51
Hydrants " " " " " .		21,406 24
Stopcocks " " " " " .		4,657 50
Hydrant and stopcock boxes, and repairing (including stock and labor)		7,267 49
Tools and repairing (including stock and labor) .		9,007 38
Streets " " " " " .		8,152 13
Fountains " " " " " .		2,483 46
Stables " " " " " .		20,477 97
Waste-detection " " " " .		25,731 04
Carried forward,		$255,341 02

Brought forward,	$255,341 02
Basins, Framingham and Ashland (including stock and labor)	7,794 13
Service-pipe repairing (including stock and labor) .	24,422 43
Protection of Sudbury and Cochituate supply . .	16,574 47
High service, Chestnut Hill (including fuel, salaries, repairs, etc.)	26,338 52
High service, East Boston (including fuel, salaries, repairs etc.)	4,849 66
High service, West Roxbury (including fuel, salaries, repairs, etc.)	3,522 13
Albany-street yard	5,544 76
Chestnut Hill Reservoir (including stable, care of grounds, etc.)	11,910 64
Parker Hill Reservoir	1,449 30
Brookline Reservoir	1,191 27
East Boston and South Boston Reservoirs . .	3,059 05
Fisher Hill Reservoir	1,604 23
Lake Cochituate	5,289 89
Chestnut Hill driveway	12,258 38
Taxes	782 05
Damages	1,355 24
Analyses of water, etc.	280 00
Merchandise sold (pipes and castings, in cases of emergency)	197 53
Filtration	7,324 89
Biological Laboratory	2,064 41
	$393,154 00

MAINTENANCE ACCOUNTS, MYSTIC WATER-WORKS.

(FROM REVENUE.)

FEBRUARY DRAFT, 1893, TO FEBRUARY DRAFT, 1894.

Boston Water Board:		
Salaries of one Commissioner and one Assistant Clerk	$5,806 40	
Printing and stationery	50 79	
Advertising, postage, travelling expenses and miscellaneous	660 55	
		$6,517 74
Superintendent's Department:		
Salaries of Superintendent, Assistant Superintendent, and Clerk	$5,762 77	
Printing and stationery	162 63	
Travelling expenses	186 25	
Miscellaneous	70 98	
		6,182 63
Engineer's Department		2,012 50
Meters, repairing		3,507 99
Off and on water (labor)		3,154 07
Main-pipe laying (including stock and labor)		4,162 80
" relaying " " " "		183 91
" repairing " " " "		1,250 69
Service-pipe laying " " " "		1,564 55
" repairing " " " "		1,019 42
Hydrants, repairing " " " "		1,957 00
Gates " " " " "		787 19
Streets, repairing " " " "		476 63
Lake		21,781 22
Conduit		1,152 12
New meters and setting		592 24
Stables		5,644 76
Reservoir		5,818 05
Pumping service (salaries, wages, fuel, repairs, etc.),		36,401 10
Repair-shop		2,624 63
Fountains		818 70
Tools and repairing		1,155 38
Mystic Sewer (repairs, and pumping and treatment of sewage)		20,717 70
Waste-Detection Service		8,597 78
Protection of water sources (including salaries of three Special Agents on Pollution)		5,669 80
Analyses of water		120 00
Filtration		2,489 77
New Pumping-engine No. 4 (on account)		4,219 53
		$151,579 90

DETAILED EXPENDITURES UNDER THE SEVERAL APPROPRIATIONS.

FEBRUARY DRAFT, 1893, TO FEBRUARY DRAFT, 1894.

Extension of Mains, etc. (from Cochituate and Mystic Revenue).

Labor	$74,990 27	
Teaming	3,444 99	
Blasting	8,383 90	
Water-pipes, contracts	82,171 85	
Stock	37,307 72	
Miscellaneous	4,222 77	
Amount paid to Park Department for Jamaica Pond Aqueduct Pipe system,	75,199 70	
		[1] $285,721 20

Additional Supply of Water (from Loans).

(Account of Basin No. 6, Whitehall pond, Cedar swamp, Protection of Supply, and Surveys and Borings for Basin No. 5.)

Salaries and labor	$47,594 54	
Materials	11,339 33	
Contract, filling on Dam No. 6, balance (total, $54,151.30)	31,284 98	
Contract, stripping Section D, Basin 6, balance (total, $56,595.80)	11,371 30	
Contract, stripping Section E, Basin 6, balance (total, $53,632.60)	13,959 81	
Contract, excavation in Basin No. 6 (on account)	5,493 44	
Contract, riprap and paving on Dam No. 6 (on account)	7,195 23	
Town of Westboro', balance of contract for a system of sewage disposal for the protection of the Boston water-supply (total, $20,000)	6,666 67	
Engineering and supplies	21,007 42	
Land damages	18,420 99	
Teaming	12,493 22	
Travelling expenses	842 69	
Printing, stationery, and advertising	570 19	
Miscellaneous	2,415 81	
		$190,655 62

[1] Stock to the amount of $29,527.63 not used, and carried into the Stock account.

High Service (from Loans).

Account of High-service Pumping-engine No. 3 for Chestnut Hill, viz.:		
Contract for engine (on account) .	$22,153 90	
Inspection	2,595 92	
Steel plates	2,256 21	
Babbitt metal	1,081 30	
Stock and labor on foundations (day-work) (total, $12,123.82) . .	3,707 26	
Contract-work, foundations (balance) (total contract, $4,566.05) . .	3,674 74	
Lining air-pump with Tobin bronze .	185 00	
Covering pump rods with brass . .	200 00	
Miscellaneous	491 72	
	$36,346 05	
High-service Fire Service:		
Stock used, paid for in previous years,	909 23	
		$37,255 28

COST OF CONSTRUCTION, AND CONDITION OF THE WATER DEBTS.

Cost of construction of Cochituate Works to February 1, 1893		$22,243,351 56
Expended from February 1, 1893, to February 1, 1894, as follows, viz.:		
Additional Supply of Water .	$190,655 62	
Extension of Mains, etc. .	256,193 57	
High Service	37,255 28	
		484,104 47
Cost of construction of Cochituate Water-Works to February 1, 1894 . . .		$22,727,456 03
The outstanding Cochituate Water Loans, February 1, 1893, were . . .		$16,758,773 98
Issued during the year 1893–94, as follows:		
Appropriation, Additional Supply of Water, 4% Loans,	$221,500 00	
" High Service, 4% Loans .	75,000 00	
		296,500 00
Total Cochituate Debt, February 1, 1894 .		$17,055,273 98
Cochituate Water Sinking-Fund, February 1, 1893		$7,019,058 38
Cochituate Water Sinking-Fund, February 1, 1894		7,649,504 87
Net Cochituate Water Debt, February 1, 1893		$9,739,715 60
Net Cochituate Water Debt, February 1, 1894		9,405,769 11
Cost of construction of Mystic Works to February 1, 1893		$1,713,227 00
Cost of construction of Mystic Works to February 1, 1894		1,721,609 33

The outstanding Mystic Water Loans, February 1, 1893, were	$440,000 00
Paid during the year 1893–94	338,000 00
Total Mystic Debt, February 1, 1894	$102,000 00
Mystic Water Sinking-Fund, February 1, 1893	$579,254 01
Mystic Water Sinking-Fund, February 1, 1894	265,210 26

TOTAL MONEY EXPENDITURES, COCHITUATE WATER-WORKS, FROM FEBRUARY 1, 1893, TO FEBRUARY 1, 1894.

Stock	$89,478 06
Labor	273,066 80
Salaries	97,828 04
Travelling expenses	10,699 21
Printing	2,184 99
Stationery	621 19
Advertising	633 68
Postage	238 95
Freights and express	942 76
Rents	2,632 91
Gas	281 75
Teaming	16,920 82
Repairs	19,242 33
Land damages, etc.	18,520 99
Taxes	676 25
Miscellaneous	11,598 32
Inspection of pipes	1,260 17
Blasting	8,392 55
Water-pipe contracts	82,685 58
Coal and wood	4,923 36
Pumping Service, salaries	11,745 25
" " fuel	9,159 58
" " repairs	1,986 55
" " oils, etc.	593 37
" " small supplies	88 13
Miscellaneous contracts	110,459 67
Engineering	25,856 40
Engineering supplies	262 78
Hay and grain	5,509 08
New meters	11,962 97
	$820,452 49
Pipe System of Jamaica Pond Aqueduct Corporation. (Purchased of Park Department.)	75,199 70
	$895,652 19

TOTAL MONEY EXPENDITURES, MYSTIC WATER-WORKS, FROM FEBRUARY 1, 1893, TO FEBRUARY 1, 1894.

Stock		$8,519 82
Labor		49,467 02
Salaries		30,104 54
Advertising		130 17
Printing		265 10
Stationery		88 12
Rents		100 00
Gas		36 80
Postage		14 00
Travelling expenses		3,680 56
Coal and wood		239 14
Freights and express		52 62
Teaming		665 66
Hay and grain		1,278 61
Repairs		1,453 44
Miscellaneous		4,624 55
Telephones		417 40
Pumping service, salaries		10,968 70
" " fuel		18,790 47
" " repairs		3,608 28
" " oils, etc.		674 50
" " small supplies		187 01
New machinery, etc.		315 00
Mystic Sewerage Station, viz.:		
Salaries and wages	$8,970 42	
Fuel	1,351 07	
Chemicals	2,898 68	
Repairs	255 44	
Small supplies	521 67	
		13,997 28
		$149,678 79

STATEMENT OF STOCK ACCOUNTS.

		Increase.	Decrease.
Cochituate Water-Works, viz.:			
Stock on hand, February 1, 1893 .	$22,561 14		
" " " February 1, 1894 .	12,336 46		
Decrease during year	$10,224 68		$10,224 68
Mystic Water-Works, viz.:			
Stock on hand, February 1, 1893 .	$3,950 18		
" " " February 1, 1894 .	2,049 07		
Decrease during year	$1,901 11		1,901 11
Extension of Mains, etc., viz.:			
Stock on hand, February 1, 1893 .	$97,467 55		
" " " February 1, 1894 .	126,995 18		
Increase during year	$29,527 63	$29,527 63	
High Service, viz.:			
Stock on hand, February 1, 1893 .	$4,313 75		
" " " February 1, 1894 .	3,404 52		
Decrease during year	$909 23		909 23
		$29,527 63	$13,035 02
Total increase in stock during year 1893-94		$16,492 61	

OUTSTANDING LOANS.

The outstanding Cochituate Water Loans at this date, February 1, 1894 (*exclusive* of the Additional Supply, $7,175,000), are as follows:

5 per cent. Sterling Loan (£399,500) . .	$1,947,273 98		Due Oct., 1902
5 per cent. Gold Loans,	100,000 00		Due April, 1906
5 per cent. Cur. Loan,	1,000 00		Due Oct., 1907
		$500,000	Due Dec., 1897
		450,000	Due June, 1898
		540,000	Due Oct., 1898
		250,000	Due April, 1899
		625,000	Due Jan., 1901
		688,000	Due April, 1901
		330,000	Due July, 1901
		413,000	Due April, 1903
		38,000	Due April, 1904
6 per cent. Loans .	4,253,000 00	161,000	Due Jan., 1905
		142,700	Due April, 1905
		6,000	Due Oct., 1905
		82,550	Due Jan., 1906
		8,750	Due April, 1906
		4,000	Due Oct., 1906
		8,000	Due Jan., 1907
		5,000	Due April, 1907
		1,000	Due July, 1907
		280,000	Due April, 1910
		111,000	Due July, 1913
		257,000	Due Jan., 1914
		50,000	Due Jan., 1915
		144,200	Due April, 1915
		23,000	Due Oct., 1915
		58,000	Due Jan., 1916
		28,500	Due April, 1916
		236,300	Due Oct., 1916
		21,000	Due Jan., 1917
4 per cent. Loans .	2,389,000 00	161,000	Due April, 1917
		7,000	Due July, 1917
		160,700	Due Oct., 1917
		20,000	Due Jan., 1918
		6,300	Due April, 1918
		100,000	Due Oct., 1918
		200,000	Due April, 1919
		250,000	Due Oct., 1920
		100,000	Due April, 1921
		100,000	Due Jan., 1922
		75,000	Due April, 1922
		50,000	Due April, 1915
		50,000	Due Oct., 1915
		100,000	Due Jan., 1916
		75,000	Due July, 1916
3½ per cent. Loans .	990,000 00	25,000	Due Oct., 1916
		240,000	Due April, 1917
		100,000	Due July, 1918
		130,000	Due Nov., 1919
		220,000	Due Jan., 1920
3 per cent. Loan . .	200,000 00		Due April, 1917
Total . . .	$9,880,273 98		

The outstanding loans on account of Additional Supply of Water on February 1, 1894, are as follows:

6 per cent. Loans . .	$644,000	$100,000	Due July, 1902
		492,000	Due April, 1903
		8,000	Due Jan., 1904
		44,000	Due July, 1905
5 per cent. Gold Loans .	3,452,000	1,000,000	Due Oct., 1905
		452,000	Due April, 1906
		2,000,000	Due Oct., 1906
5 per cent. Cur. Loan .	12,000		Due April, 1908
4½ per cent. Loan . .	268,000		Due Oct., 1909
3½ per cent. Loans . .	180,000	35,000	Due April, 1917
		145,000	Due Oct., 1919
4 per cent. Loans . .	2,619,000	588,000	Due April, 1908
		82,000	Due July, 1909
		324,000	Due April, 1912
		336,000	Due Oct., 1913
		209,000	Due Jan., 1914
		18,500	Due April, 1914
		16,000	Due Oct., 1914
		1,500	Due April, 1915
		100,000	Due April, 1916
		50,000	Due Oct., 1916
		300,000	Due Oct., 1919
		134,000	Due Oct., 1920
		162,500	Due Oct., 1921
		283,000	Due Oct., 1922
		14,500	Due Oct., 1923
Total	$7,175,000		

The outstanding Mystic Water Loan at this date, February 1, 1894, is as follows:

5 per cent. Currency Loan,	$102,000	Due April 1, 1894.

The following statement shows the appropriations by the City Council for an additional supply of water, and the amount of expenditures to February 1, 1894:

APPROPRIATIONS.

Oct. 21, 1871. — Transfer from Reserved Fund	$10,000 00
Apr. 12, 1872. — Order for Treasurer to borrow . . .	100,000 00
Apr. 11, 1873. — Order for Treasurer to borrow . . .	500,000 00
Feb. 26, 1875. — Order for Treasurer to borrow . . .	1,500,000 00
Oct. 1, 1875. — Premium on $1,000,000 bond, under order of February 26, 1875 .	83,700 00
Apr. 1, 1876. — Premium on $452,000 bonds, under order of February 26, 1875 .	47,786 80
Carried forward,	$2,241,486 80

Brought forward,	$2,241,486 80	
July 1, 1876. — Order for Treasurer to borrow . . .	2,000,000 00	
Oct. 1, 1876. — Premium on $2,000,000 bonds, under order of July 1, 1876 . .	221,400 00	
Apr. 20, 1878. — Order for Treasurer to borrow . . .	600,000 00	
Apr. 11, 1879. — Order for Treasurer to borrow . . .	350,000 00	
Aug. 17, 1881. — Order for Treasurer to borrow . . .	324,000 00	
June 2, 1883. — Order for Treasurer to borrow . . .	621,000 00	
Oct. 14, 1884. — Order for Treasurer to borrow . . .	150,000 00	
May 28, 1887. — Order for Treasurer to borrow . . .	35,000 00	
Nov. 13, 1889. — Order for Treasurer to borrow . . .	1,045,000 00	
Oct. 24, 1891. — Forfeiture of contract bond . . .	2,500 00	
Dec. 24, 1892. — Transfer . . .	20,000 00	
Apr. 26, 1893. — Order for Treasurer to borrow . . .	2,500,000 00	
		$10,110,386 80
Less transfers June 4, 1888, and January 3, 1890		12,946 48
		$10,097,440 32

EXPENDED.

1871–72	$2,302 81	
1872–73	61,278 83	
1873–74 including $20,897.50 discount on bonds sold, January, 1874,	114,102 77	
1874–75	224,956 68	
1875–76	783,613 49	
1876–77	1,924,060 24	
1877–78	1,257,715 26	
1878–79	635,658 08	
1879–80	213,350 97	
1880–81	97,406 78	
1881–82	35,677 98	
1882–83	167,621 43	
1883–84	423,625 79	
1884–85	276,292 13	
1885–86	139,187 68	
1886–87	128,109 32	
1887–88	30,332 77	
1888–89	2,398 90	
1889–90	18,518 01	
1890–91	233,710 59	
1891–92	281,271 82	
1892–93	313,844 53	
1893–94	190,655 62	
		7,555,692 48
Balance unexpended February 1, 1894		[1] $2,541,747 84

[1] $2,506,000 unnegotiated on this date.

Contracts Made and Pending during Year commencing February 1, 1893, and ending January 31, 1894.

Contracts marked with star (*) are completed. Amounts marked with (†) are for extra work.

Date.	Contractors.	Work.	Amount.	Paid on Contract. Previous Years.	Paid on Contract. Year 1893.	Paid on Contract. Total.
1890. *Apr. 26,	D. Henry Cram	Rental of derricks for use at Basin No. 6	$200 each 1st year, $100 each after,	$2,400 00	$100 00	$2,500 00
1891. *May 26,	Town of Westboro'	System of sewage disposal to remove sewage of town outside of Sudbury river water-shed	$20,000	13,333 33	6,666 67	20,000 00
*July 15,	Moulton, O'Mahoney, & Trumbull	Excavation, Section D, Basin No. 6	62 cents per cubic yard	45,224 50	11,371 30	56,595 80
*Oct. 5,	Barnabas Clarke	Filling on Dam. No. 6, Ashland (for completion of Charles H. Hale's contract)	Same as under Hale's contract of January 29, 1891, viz.: $57,300 (estimated), and $2,500 additional on completion of work	25,366 32	28,784 98 †2,500 00	56,651 30
1892. *Jan. 13,	John Berry & Co.	Excavation, Section E, Basin No. 6	$47,786 (estimated)	39,672 79	13,959 81	53,632 60
*Feb. 25,	Radford Pipe and Foundry Company	2,920 tons water-pipes, 150 tons specials	$25.40 per ton 2,240 lbs. for pipes $50.40 " " " specials	57,991 14	8,262 12	66,253 26
*Mar. 14,	Pierce F. Lonergan	Teaming pipes, etc., for year ending March 15, 1893	69 cents per ton 2½ miles $1.49 " " over 2½ miles	2,418 83	178 14	2,596 97
* " 15,	Stephen Anderson	Brass castings	Composition No. 1, 18c. per lb. " No. 2, 15½c. " " No. 3, 14½c. "	3,813 92	1,970 02	5,783 94

*Mar. 15,	Osgood & Hart	Iron and service-box castings	1 19-20 cents per lb.	9,415 56	4,168 52	13,584 08
June 8, Modifi'd Aug. 1,	N. F. Palmer, Jr., & Co.	High-service Pumping-engine No. 3	$124,000 3,500 Less on account Modification. $120,500	42,277 82	22,153 90	64,431 72
*Sept. 2,	Donovan & Brock	Foundations for high-service Pumping-engine No. 3	$4.90 per cubic yd. brick masonry, $65 " " capstone, etc.	891.31	3,674 74	4,566 05
" 29,	Lamprey Boiler Furnace Mouth Protector Co.	Attachment to boilers at pumping-stations 6 mos. trial free of expense to city	$90 per boiler, if iron } if $105 " if brass } accepted.	Payments delayed.		
1893. *Jan. 10,	Wellman Iron and Steel Company	Steel plates for high-service Pumping-engine No. 3	$4\frac{1}{2}$ cents per lb., delivered	. . . . . .	2,256 21	2,256 21
* " 25,	R. D. Wood & Company	10 tons 4-inch B pipe, 600 tons 6-inch B pipe, 400 tons 8-inch B pipe, 100 tons 16-inch A pipe, 390 tons 24-inch A pipe, 1,100 tons 36-inch A pipe 100 tons special castings	$25.94 per ton $25.21 " $25.60 "	. . . . . .	68,589 22	68,589 22
* " 28,	N. F. Palmer, Jr., & Co.	Covering with brass 3 pump-rods for Pumping-engine No. 3	$200	. . . . . .	. . . . . .	200 00
*Mar. 2,	Townsend & Olsen	Repairing submerged pipe between Moon and Long Islands	$75 per day	. . . . . .	2,712 50	2,712 50
" 6,	Osgood & Hart	Iron and service-box castings	1 19-20 cents per lb.	. . . . . .	9,241 48	9,241 48
" 6,	Granular Metal Company,	Brass castings	Composition, No. 1, $17\frac{1}{2}$ c. per lb. " " 2, 15 c. " " " " 3, 14 c. " "	. . . . . .	3,388 15	3,388 15
" 6,	Daniel Doherty	Teaming pipes, etc., for year ending March 15, 1894	$0.70 per ton, $2\frac{1}{2}$ miles $1.20 " " over $2\frac{1}{2}$ miles	. . . . . .	1,970 09	1,970 09
* " 14,	Warren Foundry & Machine Company	37 tons 6-inch flexible joint pipe	$38.50	. . . . . .	1,417 25	1,417 25
* " 23,	Thomas Burke	Blasting, Sachem street, Roxbury	$3.37 per cubic yard	. . . . . .	91 66	91 66
* " 25,	Martin F. Kelley	Blasting, Holborn street, Roxbury	$2.44 per cubic yard	. . . . . .	212 28	212 28
*Apr. 4,	Thomas Burke	Blasting, Greenheys street, Dorchester	$3.24 per cubic yard	. . . . . .	263 09	263 09

Contracts Made and Pending during the Year. — *Continued.*

Date.	Contractors.	Work.	Amount.	Paid on Contract. Previous Years.	Year 1893.	Total.
1893. *Apr. 4,	Martin F. Kelley	Blasting, Dewey street, Dorchester	$4.87 per cubic yard	......	$848 35	$848 35
* " 4,	N. F. Palmer, Jr., & Co.	Lining air-pump with Tobin bronze	$185	......	185 00	185 00
" 15,	Atlantic Works	Belpaire boiler for Pumping-engine No. 3	$10,612.33 f. o. b. cars.			
*May 1,	Auguste Saucier	Building Natick filter-beds	$4,234.70	......	5,013 69	5,013 69
* " 9,	Martin F. Kelley	Blasting, Rockwood street, West Roxbury	$3.25 per cubic yard	......	378 30	378 30
* " 10,	Thomas Burke	Blasting, Peter Parley road, West Roxbury	$4.48 per cubic yard	......	67 65	67 65
* " 13,	Thomas Burke	Blasting, Franklin Park terrace, West Roxbury	$3.18 per cubic yard	......	446 47	446 47
* " 17,	Wm. L. O'Connell	Blasting, Eugene street, West Roxbury	$2.98 per cubic yard	......	118 01	118 01
* " 23,	J. C. Coleman	Blasting, Chamblet street, Dorchester	$2.23 per cubic yard	......	369 73	369 73
*June 2,	Martin F. Kelley	Blasting, Chiswick road, Brighton	$2.93 per cubic yard	......	130 39	130 39
* " 9,	Martin F. Kelley	Blasting, Bowdoin street, Dorchester	$2.90 per cubic yard	......	114 55	114 55
*July 1,	Wm. L. O'Connell	Blasting, Bowdoin street, Dorchester	$3.98 per cubic yard	......	46 96	46 96
* " 3,	Thomas Burke	Blasting, Penryth street, Roxbury	$3.68 per cubic yard	......	23 18	23 18
* " 12,	E. D. Leavitt, M.E.	Design and specifications for 10 million gallon pumping-engine for the Mystic Pumping-Station	$4,000	......	4,000 00	4,000 00
* " 20,	Wm. L. O'Connell	Blasting, Virginia street, Dorchester	$2.98 per cubic yard	......	97 15	97 15
* " 25,	Thomas & Co.	1,500 tons Cumberland coal delivered in bins, Mystic Pumping Station	$4.31	......	7,021 05	7,021 05

July 25,	Moulton & O'Mahoney	Building Dam No. 5, Southboro'	$454,729.90 paved. $446,829.90 riprapped.			
*Aug. 5,	Coffin Valve Company	Two 36-inch sluice-gates delivered and set up at Basin No. 6	$1,250		1,250 00	1,250 00
* " 5,	Coffin Valve Company	One 36-inch check-valve delivered at 710 Albany st.	$1,025		1,025 00	1,025 00
* " 18,	Martin F. Kelley	Blasting, Dalmatia street, Roxbury	$2.36 per cubic yard		52 86	52 86
*Sept. 5,	Thomas Burke	Blasting, Stockton street, Dorchester	$3.48 per cubic yard		189 66	189 66
* " 18,	John Cavanagh & Co.	Laying about 1,200 linear feet 6-inch flexible joint-pipe between Moon and Long Islands to replace that broken by frost	83 cents per linear foot		2,100 00	2,100 00
" 19,	John Berry	Laying paving and riprap on Dam No. 6	$14,145.91		7,195 23	7,195 23
* " 25,	John W. Bowers	Blasting, Vose street, Dorchester	$2.49 per cubic yard		30 38	30 38
* " 27,	Cannon & Gunning	Blasting, Quint street, Brighton	$4.40 per cubic yard		111 32	111 32
* " 29,	Martin F. Kelley	Blasting, Wolcott street, Dorchester	$1.99 per cubic yard		169 75	169 75
*Oct. 2,	Auguste Saucier	Excavation for stripping and shallow flowage in Basin No. 6	$34\frac{1}{2}$ cents per cubic yard		5,493 44	5,493 44
* " 6,	Thomas Burke	Blasting, Oakley avenue, Dorchester	$3.38 per cubic yard		25 01	25 01
* " 14,	James Dolan	Blasting, Ritchie street, Roxbury	$3.40 per cubic yard		93 84	93 84
* " 24,	Curran & Burton	600 tons Pocahontas coal, delivered in bins at Chestnut Hill Pumping-Station	$4.75 per ton		2,883 63	2,883 63
* " 30,	Martin F. Kelley	Blasting, Kalada park, Roxbury	$2 per cubic yard		30 40	30 40
*Nov. 18,	Thomas Burke	Blasting, Williams street, Franklin Park	$2.73 per cubic yard		239 97	239 97
* " 22,	Martin F. Kelley	Blasting, Seaver street, West Roxbury	$3.18 per cubic yard		145 33	145 33
Dec. 26,	Thomas Prosser & Son	Steel forgings for the Mystic Pumping-Station	$2,065.15.			
" 28,	Curran & Burton	1,000 tons Pocahontas coal, delivered in bins at the Mystic Pumping-Station	4.32\frac{1}{2}$ per ton, 2,240 lbs.			

REPORT OF THE SUPERINTENDENT OF THE EASTERN DIVISION.

OFFICE OF SUPERINTENDENT OF EASTERN DIVISION,
710 ALBANY STREET, BOSTON, February 1, 1894.

COL. THOMAS F. DOHERTY,
Chairman Boston Water Board:

DEAR SIR: I herewith respectfully submit the annual report of the Eastern Division for the year ending January 31, 1894:

DISTRIBUTION OF MAINS.

Two hundred and ten petitions for extension of mains have been received, and 176, including 20 of 1892, have been granted and the mains extended.

Over 16 miles of main pipe have been laid, and 10,776 feet of pipe have been abandoned, making a total of 550.06 miles; and 10 miles of main pipe bought of the Jamaica Pond Aqueduct added to this makes the total number of miles now connected with the system 560.06.

STOP-COCKS.

During the year 296 stop-cocks were established and 24 were abandoned, making an increase of 272; and 50 which are on the Jamaica Pond system added to this make a total of 6,182 stop-cocks connected with the system.

HYDRANTS.

Two hundred and fifty-six hydrants were established, and 67 were abandoned, making a net increase of 189, and 6,042 now connected with the system.

SERVICE-PIPES.

One thousand eight hundred and eighty-nine service-pipes have been laid, with an aggregate length of 45,393 feet, and 377 have been abandoned, making the net increase 1,512 during the year.

METERS.

Cochituate Division. — Two hundred and forty-eight meters have been set and 110 have been discontinued,

making a net increase of 138, and a total of 4,046 now in use.

Mystic Division. — Forty-six meters have been set and 14 discontinued, making the net increase 32, and the total number in use 461.

Water-Posts.

Twenty-four water-posts were erected and 3 abandoned, making the number now in use 341.

Fountains.

During the year there were 4 fountains erected and 1 abandoned.

Waste Detection.

Premises examined	82,501
Defective fixtures	12,609
Reëxaminations	12,827
Second notice to repair issued	1,423
Wilful-waste notices issued	94

The defective fixtures may be divided into the following classes:

Ball-cocks	7,314
Faucets, sink, bowl, hopper, and bath-tub . .	5,515
Water-closets	176
Services burst inside building	675
Services burst outside building	94
Wilful waste	94

In connection with the meters, out of 2,718 night examinations by means of the sidewalk shut-offs, there were 1,010 detections of defective fixtures. There were also 479 hand-hose reported for non-payment.

Deacon Waste Meter System.

There are now in use 83 meters, 76 on the Cochituate, and 7 on the Mystic system. The territory supplied by the meters is divided into 176 sections.

For various reasons 10 of the sections were not tested during the year.

Last May 2 meters having been set in the Back Bay district, the entire residential portion of Boston can now be

tested by the meters, with the exception of a portion of West Roxbury and a small portion of Dorchester.

Neither of these portions can be advantageously tested until the districts are more densely settled.

On the Mystic system, Charlestown, which was practically covered by meters, has been disarranged owing to the introduction of the high service to a part of the system.

The meter at Pearl street will be useless in its present location, and 4 sections on the other meters cannot be tested. One meter supplies about one-fourth of Chelsea. The Somerville meter has not been worked during the year owing to a lack of proper connections.

Everett as yet has no meter.

The estimated population supplied with water as obtained from the Water Registrar's books, and the population that is supplied through the Deacon meters in the different sections of the city, is as follows:

	Estimated population.	Population on meters.
City Proper	168,500	142,650
Roxbury	128,100	87,950
West Roxbury	16,800	5,400
Dorchester	41,200	33.800
Brighton	15,800	8,800
South Boston	73,000	67,350
East Boston	43,800	33,500
Charlestown	48,200	30,200
Chelsea	37,000	9,650
Somerville	58,800	
Everett	17,800	

The consolidated results of the readings of the various sections is shown in the following summary, in which is given the final readings of the year 1892, and the first and final readings of the year 1893:

System.	1892.			1893.				
	Population.	2d Reading.		Population.	1st Reading.		2d Reading.	
		Daily consumption.	Night rate.		Daily consumption.	Night rate.	Daily consumption.	Night rate.
		Gallons.	*Gallons.*		*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
Cochituate .	337,900	54.2	35.0	379,450	54.48	36.69	54.78	37.88
Mystic . . .	42,600	43.0	27.3	39,850	44.12	28.18	44.12	28.18

Statement of Location, Size, and Number of Feet of Pipe Laid in 1893.

NOTE. — B., indicates Boston; S.B., South Boston; E.B., East Boston; Rox., Roxbury; Dor., Dorchester; W.Rox., West Roxbury; Bri., Brighton.

In what Street.	Between what Streets.	District.	Size.	Length.
Congress	B and C	S.B.	16 in.	624
Ashby	Commonwealth ave. and St. Mary . . .	Rox.	"	98
Commonwealth ave. .	Deerfield and Ashby	"	"	1,883
Roxbury	Elmwood and Pynchon	"	"	98
Terrace	Heath and Cedar	"	"	92
	Total 16-inch.	. . . .	. . .	2,795
Atlantic ave.	Pearl and Oliver	B.	12 in.	205
Columbus ave.	Camden and Davenport	"	"	144
Deerfield	Commonwealth ave. and Bay State road .	"	"	383
Devonshire	Spring lane and Water	"	"	45
Milk	Oliver and Batterymarch	"	"	149
Spring lane	Washington and Devonshire	"	"	243
Washington	Haymarket sq. and Friend	"	"	294
East Second	From Q	S.B.	"	32
L	First and Congress	"	"	1,048
Sleeper	Congress and N. Y. & N. E. R.R.	"	"	221
Swett	Boston " "	"	"	210
Audubon road.	Boylston and B. & A. R.R.	Rox.	"	812
Brookline ave.	Riverway and Audubon road	"	"	31
Bumstead lane	Smith and Tremont	"	"	339
Blue Hill ave.	Otisfield and Warren	"	"	793
Commonwealth ave. .	Deerfield and Ashby	"	"	41
Holborn	Blue Hill ave. and Holborn park	"	"	231
Lawn	From Hayden.	"	"	197
Magazine	Kemble and East Chester park	"	"	573
Riverway	Huntington ave. and Tremont	"	"	283
Ritchie	Amory and Centre	"	"	231
Tremont-st. entrance to Park	Huntington ave. and Riverway	"	"	494
East Chester park . . .	Boston and Clapp	Dor.	"	218
Dewey	Howard ave. and Danube	"	"	316
	Carried forward	. . . .	. . .	7,533

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	Brought forward	......	...	7,533
Glen road	Harvard and White	Dor.	12 in.	57
Geneva ave.	Westville and Bowdoin	"	"	306
Morton	Wildwood and Blue Hill ave.	"	"	564
Park	Vinson and Washington	"	"	533
Romsey	Sagamore and Dorchester ave.	"	"	22
Sydney	Romsey and Harbor View	"	"	62
Stockton	Washington and Milton ave.	"	"	1,190
Arbor Way	Pond and Perkins	W.R.	"	715
" "	Washington and Forest Hill	"	"	1,392
Brandon	Aldrich and Arden	"	"	1,050
Beech	Orange and Newberg	"	"	529
Baker	Prospect and Belle ave.	"	"	220
Belle ave.	From Baker	"	"	1,050
Bellevue ave.	Brook and Dudley ave.	"	"	60
Montclair ave.	Centre and Merlin	"	"	160
Neponset ave.	Canterbury and Folsom	"	"	122
Newberg	Brandon and Berry	"	"	128
Robinswood	Centre and Enfield	"	"	1,002
Vermont ave.	Corey and Mt. Vernon	"	"	249
Commonwealth ave.	St. Mary and St. Paul	Bri.	"	2,358
Cambridge	Harvard and Royal road	"	"	859
Parsons	Faneuil and North Beacon	"	"	60
South	Foster and Lake	"	"	911
	Total 12-inch	......	...	21,132
Oliver	Milk and Franklin	B.	10 in.	42
Mountfort	Arundel and St. Mary	Rox.	"	156
	Total 10-inch	......	...	198
Bay State road	Raleigh and Deerfield	B.	8 in.	551
Bothnia	Belvidere and Boylston	"	"	427
Cottage place	Washington and Harrison ave.	"	"	343
Dalton	Scotia and Cambria	"	"	6
Lincoln	Essex and Tufts	"	"	252
Thorndike	Reed and Harrison ave.	"	"	212
	Carried forward	......	...	1,791

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	Brought forward	. . . . . .	. . .	1,791
Turner	From Haviland	B.	8 in.	313
W. Newbury	Charlesgate West and Kenmore	"	"	104
Rawson	Boston and Dorchester ave.	S.B.	"	48
Wormwood	A and N.Y. & N.E. R.R.	"	"	484
Gladstone	Breed and Chelsea	E.B.	"	162
Avon	Ruggles and Greenleaf	Rox.	"	300
Ashby	Bay State road and Commonwealth ave.,	"	"	14
Granby	" " " " " "	"	"	24
Island	Gerard and Hampden	"	"	755
Pontine	From Norfolk ave.	"	"	36
Sherborn	Bay State road and Commonwealth ave.,	"	"	17
Bowdoin	Bullard and Mt. Bowdoin ave.	Dor.	"	185
Chamblet	Hartford and Magnolia	"	"	499
Fulton	Water and Ericsson	"	"	1,029
Glendale	Columbia and Bird	"	"	300
Holden	From Boston	"	"	200
Mt. Vernon	Buttonwood and Von Hilleran	"	"	124
Mt. Hope ave.	From Blue Hill ave.	"	"	190
Melville ave.	Upland ave. and N.Y., N.H., & H. R.R. .	"	"	269
Milton	Adams and N.Y., N.H., & H. R.R. . . .	"	"	228
Torrey	Learnard and Withington	"	"	204
Walcott	Columbia and Erie ave.	"	"	701
Waldeck	Park and Lindsay	"	"	495
Arbor Way	Pond and Centre	W.R.	"	2,667
Ashland	Canterbury and Hyde Park ave.	"	"	232
"	Sherwood and Brown ave.	"	"	125
Aldrich	Berry and Beech	"	"	268
Clarendon ave.	Hilburn and Augustus ave.	"	"	180
Clement ave.	Park and Farrington	"	"	326
Forest Hills	Green and Williams	"	"	265
Knoll	Selwyn and Centre	"	"	206
Kenneth	Stratford and Farrington ave.	"	"	371
Peter Parley road . .	Forest Hills and Walnut ave.	"	"	1,171
Proctor	Walter and Fairview	"	"	192
	Carried forward	. . . .	. . .	14,475

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	Brought forward	. . . . . .	. . .	14,475
Paine	Canterbury and Walk Hill	W.R.	8 in.	56
Roslindale ave.	Auburn and Dudley ave.	"	"	219
Rockwood	Pond and Brookline line	"	"	620
Sedgwick	Elm and South	"	"	233
Stratford	Clement and Anawan ave.	"	"	379
Schuman	Washington and Nikisch	"	"	208
Weld Hill	From Wenham	"	"	275
Chilmark	Commonwealth ave. and Bay State road	Bri.	"	26
Chiswick road	Selkirk and Fenwick roads	"	"	467
Eleanor	Cambridge and Ridgemont	"	"	190
George	North Beacon and Spring	"	"	20
Hill	Murdock and Lucas	"	"	104
Lincoln	Franklin and Cambridge	"	"	417
Ridgemont	Eleanor and Allston Heights	"	"	382
Summit ave.	Allston and Summer	"	"	131
	Total 8-inch	. . . . . .	. . .	18,202
Battery wharf	From Commercial	B.	6 in.	33
Chauncy	Essex and Rowe place	"	"	238
Cambria	Dalton and Bothnia	"	"	190
Clarendon	St. James and B. & A. R.R.	"	"	24
Devonshire	Water and State	"	"	73
Gilbert place	Summer and Congress	"	"	257
Hathaway	" " "	"	"	376
Kenmore	Commonwealth ave. and W. Newbury	"	"	239
McLellan	From Reed	"	"	66
Mystic	E. Canton and Brookline	"	"	106
Scotia	Bothnia and Dalton	"	"	72
Prescott	Saratoga and Bennington	E.B.	"	251
Pope	Curtis and Pope-st. court	"	"	109
Pope-st. court	From Pope	"	"	163
Dunham park	" Fifth	S. B.	"	28
East Fifth	H and I	"	"	68
H	Fourth and Fifth	"	"	323
I	" " Sixth	"	"	147
	Carried forward	. . . . . .	. . .	2,867

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	Brought forward	. . . . . .	. . .	2,867
Story	G and H	S.B.	6 in.	150
Bay State road	Deerfield and Sherborn	Rox.	"	785
Batavia	St. Stephen and Parker	"	"	504
Crestwood terrace	From Townsend	"	"	254
Dunford	Cobden and Fenner	"	"	187
Dalmatia	Howard and Blue Hill aves.	"	"	244
Devon	Warren and Blue Hill ave.	"	"	48
Deerfield	Bay State road and the water	"	"	153
Dacia	Dewey and Dove	"	"	290
Heath	Parker and Bickford ave.	"	"	578
Homer place	Winthrop and Moreland	"	"	150
Intervale	Warren and Blue Hill ave.	"	"	42
Kalada park	From Holborn	"	"	131
Magazine	Dunmore and Dudley	"	"	77
Miner	Beacon and B. & A. R.R.	"	"	373
Penryth	Centre and Pynchon	"	"	162
Sunderland	Warren and Blue Hill ave.	"	"	65
Sachem	Calumet and Hillside	"	"	149
Vine	Dudley and Forest	"	"	24
Wait	Tremont and Hillside	"	"	137
Ashmont	Newhall and Neponset ave.	Dor.	"	809
Auckland	Elton and Savin Hill ave.	"	"	306
Auckland	Belfort and Elton	"	"	140
Brook	Patterson and Dorchester ave.	"	"	82
Bloomington	Tolman and Eaton	"	"	94
Bicknell	Harvard and White	"	"	255
Buttonwood	Grafton and Crescent ave.	"	"	378
Bowdoin	Hancock and Church	"	"	209
Baker court	From Willow court	"	"	36
Bellows place	" Dorchester ave.	"	"	140
Bertram	" Neponset ave.	"	"	19
Chapman ave.	Tucker and Birch	"	"	94
Columbia terrace	From Richfield	"	"	84
Chamberlain	Harvard and Cook	"	"	60
	Carried forward	. . . . . .	. . .	10,076

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	Brought forward	. . . . . .	. . .	10,076
Crescent ave.	Spring Garden and Sydney	Dor.	6 in.	48
Clarkson	Barrington and Mullaney	"	"	266
Danube	Brookford and Dewey	"	"	169
Dalkeith	From Howard ave.	"	"	173
Ditson	Leroy and Josephine	"	"	79
Evansdale terrace . .	From Savin Hill ave.	"	"	203
Elmont	Waterlow and Washington	"	"	108
Ellet	Adams and Dorchester ave.	"	"	117
Ericsson	Fulton and High	"	"	72
Fulton	Water and Franklin	"	"	31
Freeman	Faulkner and Charles	"	"	87
Greenheys	Cedar and Magnolia	"	"	281
Houghton	Mill and Tileston place	"	"	51
Howell	Boston and Dorchester ave.	"	"	525
Harlow	From Howard ave.	"	"	19
Hartland	Sydney and Tuttle ave.	"	"	52
Harrison park	From Beach	"	"	190
Josephine	Ditson and Geneva ave.	"	"	175
Longfellow	Topliff and Ditson	"	"	1,045
Marshfield	Clifton and Batchelder	"	"	143
Mascot	From Mountain ave.	"	"	136
Mt. Bowdoin Green .	Mt. Bowdoin and Mt. Bowdoin	"	"	225
Mullaney	From Clarkson	"	"	58
Neponset ave.	Ashmont and Neponset bridge	"	"	2,996
Oakley	Bowdoin and Geneva ave.	"	"	830
Oak ave.	Adams and Plain	"	"	615
Shelton	Adams and Wrentham	"	"	365
Spencer	Park and Wheatland ave.	"	"	156
Sawyer	Downer and Cushing ave.	"	"	202
Saco	From Neponset ave.	"	"	48
Stratford	From Waldeck	"	"	331
Street	Clayton and N.Y., N.H., & H. R.R. . .	"	"	92
Sidney place	From Waterlow	"	"	60
Sydney	Harbor View and Crescent ave.	"	"	117
	Carried forward	. . . .	. . .	20,141

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	Brought forward	. . . . . .	. . .	20,141
Sagamore	Belford and Romsey	Dor.	6 in.	154
Train	King and Mill	"	"	213
Tuttle ave.	Hartland and Savin Hill ave.	"	"	10
Vose	Butler and Crest ave.	"	"	100
Virginia	Bird and Arion	"	"	128
Warner ave.	Coolidge and Park	"	"	48
Wrentham	Ashmont and Shelton	"	"	60
"	Shelton and Dorchester ave.	"	"	52
Arbor way	Morton and Forest Hills	W.R.	"	1,032
Austin Farm	From Canterbury	"	"	211
Auburn	Bellevue and Roslindale	"	"	243
Asbury place	From South	"	"	246
Boynton	South and New Call	"	"	182
Berry	Cornell and Brooks	"	"	120
Clement ave.	Stratford and Farrington ave.	"	"	12
Elgin	Hilcrest and N.Y., N.H., & H. R.R. . . .	"	"	75
Eldridge	From Metropolitan ave.	"	"	183
Eugene	Forest Hills and Peter Parley road . . .	"	"	630
Folsom	Florence and Mt. Hope	"	"	628
Flora	Kenneth and Clement ave.	"	"	163
Frisno	Alder and Dudley ave.	"	"	95
Franklin Park terrace .	Eugene and Walnut ave.	"	"	573
Garden	Sherwood and Brown ave.	"	"	136
Goldsmith	Centre and Jamaica	"	"	225
Hillburn	Poplar and Clarendon ave.	"	"	248
Hadwin way	Hammet road and Hyde Park ave. . . .	"	"	175
Hastings	Centre and Carl	"	"	17
Hall	South and New Call	"	"	153
Locksley	From Robinswood	"	"	377
Mozart ave.	Walter and Selwyn	"	"	242
Myers	From Spruce	"	"	48
Newburg	Brandon and Beech	"	"	1,105
Newbern	Elm and Bishop	"	"	144
Norfolk	Washington and Kittredge	"	"	163
	Carried forward	. . . . . .	. . .	28,332

Statement of Location, Size, etc.— *Concluded.*

In what Street.	Between what Streets.	District.	Size.	Length.
	Brought forward	. . . . . .	. . .	28,332
Pierce Farm	From Walk Hill	W.R.	6 in.	1,935
Perham	Ivory and N.Y., N.H., & H. R.R.	"	"	115
Perham	Ivory and Winslow	"	"	205
Starr lane	Centre and Seaverns ave.	"	"	126
So. Fairview	South and Brookfield	"	"	42
Street	Boylston ave. and N.Y., N.H., & H. R.R.	"	"	130
Taft's place	From South	"	"	239
Alcott	Franklin and Mansfield	Bri.	"	191
Bentley	Sparhawk and Henshaw	"	"	529
Bayard	Kenneth and No. Harvard	"	"	239
Chestnut Hill reservoir	From South	"	"	442
Chiswick road	Selkirk road and Commonwealth ave. .	"	"	74
Callahan place	From Western ave.	"	"	270
Cambridge terrace . .	From Cambridge	"	"	214
Garden	Murdock and Lucas	"	"	60
Highland ave.	From Cambridge	"	"	117
Leicester	Bennet and Arlington	"	"	339
Linden	Cambridge and Pratt	"	"	226
Mansfield	Cambridge and Alcott	"	"	216
Quint ave.	From Brighton ave.	"	"	359
Spring	George and Market	"	"	445
Windsor road	From Lanark road	"	"	70
Westford	From Raymond	"	"	72
Weitz	Franklin and Bayard	"	"	110
Bellevue ave.	From Huckins ave.	Quincy.	"	67
Huckins ave.	Squantum and Bellevue	"	"	15
Long Island	Moon and Long Island	. . . . . .	"	1,700
Long Island	For reservoir	. . . . . .	"	384
	Total 6-inch	. . . . . .	. . .	37,263
Street	From Dacia	Rox.	4 in.	149
Street	From Savin Hill ave.	Dor.	"	141
Rainsford Island line	On Long Island	. . . . . .	"	1,300
	On Rainsford Island	. . . . . .	"	2,300
	Total 4-inch	. . . . . .	. . .	3,890
	Long and Rainsford Islands	. . . . . .	3-in.	2,200

Statement of Pipes Raised, Lowered, and Abandoned.

In what Street.	Between what Streets.	District.	Size.	Length.
	RAISED.			
Tremont	Brookline line	Rox.	36	72
Tremont	Brookline line	"	30	70
Commonwealth ave.	St. Mary and Essex	Bri.	16	1,050
Commonwealth ave.	Beacon and St. Mary	Rox.	12	2,400
Cambridge	Harvard and Royal road	Bri.	"	241
Mansfield	Cambridge and Alcott	"	6	86
Linden	Cambridge and Pratt	"	"	50
	LOWERED.			
Peter Parley road	Forest Hills and Eugene	W.R.	8	275
Eldora	Hillside and Sunset	Rox.	6	165
	RELAID.			
Norfolk ave.	Franklin court and Magazine	"	12	665
	ABANDONED.			
Roxbury	Gardner and Pynchon	"	20	90
Elmwood	Roxbury and Texas	"	16	135
Commonwealth ave.	St. Paul and Essex	Bri.	"	960
	Total 16-inch	....	....	1,095
Seaver	Humboldt and Walnut aves.	Rox.	12	1,195
Cambridge	Harvard and Royal road	Bri.	"	851
	Total 12-inch	....	....	2,046
Lincoln	Franklin and Cambridge	Bri.	8	136
Lincoln	Essex and Tufts	B.	6	252
Fourth	Foundry and N.Y., N.H., & H. R.R.	S.B.	"	425
Terrace	Heath and Cedar	Rox.	"	75
Washington	Eustis and Ball	"	"	610
Eustis	Washington and Harrison ave.	"	"	365
Ericsson	Fulton and High	Dor.	"	45
Neponset ave.	Neponset bridge and R.R.	"	"	130
Mansfield	Franklin and Cambridge	Bri.	"	216
Highland ave.	From Cambridge	"	"	117
Linden	Pratt and Cambridge	"	"	320
Long Island	Long and Moon Islands	....	"	1,700
	Total 6-inch	....	....	4,255

Statement of Pipes Abandoned, etc. — *Concluded.*

In what Street.	Between what Streets.	District.	Size.	Length.
Spring lane	Washington and Devonshire	B.	4	243
Essex place	From Tufts	"	"	36
Cottage place	Washington and Harrison ave.	"	"	343
Avon	Ruggles and Greenleaf	Rox.	"	188
Ball	Washington and Shawmut ave.	"	"	295
Madison	Washington and Shawmut ave.	"	"	485
Webber	Albany and Harrison ave.	"	"	160
	Total 4-inch	....	....	1,750
Ambrose	Albany and Orchard	Rox.	3	300
Mall	Albany and Eustis	"	"	680
Reed's court	Yeoman and Ambrose	"	"	254
Shawmut ave.	Vernon and Ruggles	"	"	170
	Total 3-inch	....	....	1,404

	Diameter of Pipes in Inches.															
	60	48	40	36	30	28	24	20	16	12	10	8	6	4	3	
Eastern Division.																
Length in use Jan. 31, 1893,	. . .	25,571	23,054	20,844	60,974	244	58,064	59,484	70,771	794,776	45,037	334,011	1,186,552	126,549	. . . .	2,805,931
Stopcocks in same	. . .	1	7	14	25	. . .	49	37	101	1,210	60	652	3,097	641	. . . .	5,894
Length bought of Jamaica Pond Aqueduct	. . .	. . . .	. . . .	. . . .	. . . .	. . .	. . . .	. . . .	. . . .	11,880	3,960	3,960	13,200	9,240	10,560	52,800
Stopcocks in same	. . .	. . . .	. . . .	. . . .	. . . .	. . .	. . . .	. . . .	. . . .	4	4	2	17	16	7	50
Length laid or relaid during the year	. . .	. . . .	. . . .	. . . .	. . . .	. . .	. . . .	. . . .	2,795	21,132	198	18,202	37,263	3,890	2,200	85,680
Stopcocks in same	. . .	. . . .	. . . .	. . . .	. . . .	. . .	. . . .	. . . .	7	45	1	46	142	5	. . . .	246
Length abandoned during the year	. . .	. . . .	. . . .	. . . .	. . . .	. . .	. . . .	90	1,095	2,046	. . . .	136	4,255	1,750	1,404	10,776
Stopcocks in same	. . .	. . . .	. . . .	. . . .	. . . .	. . .	. . . .	. . . .	1	4	. . . .	2	12	5	. . . .	24
Length in use Jan. 31, 1894,	. . .	25,571	23,054	20,844	60,974	244	58,064	59,394	72,471	825,742	49,195	356,037	1,232,760	137,929	11,356	2,933,635
Western Division.																
Length in use Jan. 31, 1894,	266	16,051	1,435	1,166	2,140	. . .	. . . .	. . . .	20	2,043	. . . .	. . . .	360	. . .	. . . .	23,481
Stopcocks in same	. . .	5	. . . .	3	. . . .	. . .	. . .	. . . .	2	4	. . . .	. . . .	2	. . . .	. . . .	16
Total connected with works Jan. 31, 1894	266	41,622	24,489	22,010	63,114	244	58,064	59,394	72,491	827,785	49,195	356,037	1,233,120	137,929	11,356	2,957,116 or 560.06 miles.

Statement of Hydrant, Blow-Off, and Reservoir Pipes, January 31, 1894.

	Diameter in Inches.						Total.
	16	12	9	8	6	4	
Total length in use January 31, 1893	272	6,847	3,023	28	16,304	10,832	37,306
Length laid or relaid during the year	......	100	......	......	1,629	43	1,772
Length abandoned during the year	......	9	30	......	74	87	200
	272	6,938	2,993	28	17,859	10,788	38,878

Statement of Service Pipes Laid and Abandoned during the Year ending January 31, 1894.

SIZE OF SERVICE.	BOSTON.		SOUTH BOSTON.		EAST BOSTON.		ROXBURY.		DORCHESTER.		WEST ROXBURY.		BRIGHTON.		TOTAL.	
	Number of Services.	Length in Feet.	Number of Services.	Length in Feet.	Number of Services.	Length in Feet.	Number of Services.	Length in Feet.	Number of Services.	Length in Feet.	Number of Services.	Length in Feet.	Number of Services.	Length in Feet.	Number of Services.	Length in feet.
6 inch laid	1	11	....	...	....	....	....	....	....	....	....	....	....	....	1	11
4 " "	45	937	1	21	1	5	2	39	1	26	4	506	1	50	55	1,584
4 " abandoned	1	....	....	....	....	....	....	....	....	....	....	....	1	50	2	50
3 " laid	12	346	....	....	2	80	3	113	4	118	....	....	....	....	21	657
3 " abandoned	3	44	....	....	....	....	1	26	....	....	....	....	....	....	4	70
2 " laid	10	157	....	....	2	26	....	....	1	17	....	....	1	18	14	218
2 " abandoned	....	....	....	....	....	....	2	6	1	15	....	....	1	6	4	27
1½ " laid	21	603	1	30	3	54	3	122	2	57	1	30	....	....	31	896
1½ " abandoned	1	12	....	....	....	....	1	31	....	....	....	....	....	....	2	43
1¼ " laid	9	268	2	71	....	....	3	82	....	..	4	59	1	33	19	513
1¼ " abandoned	2	39	....	....	....	....	1	40	....	....	....	....	....	....	3	79
1 " laid	42	1,039	2	82	4	61	20	647	1	33	8	175	1	53	78	2,090
1 " abandoned	12	216	2	86	1	6	3	101	3	52	....	....	....	....	21	461
¾ " laid	34	948	2	73	1	41	57	1,717	4	130	4	158	....	....	102	3,067
¾ " abandoned	6	148	....	....	....	....	6	114	....	....	....	....	....	....	12	262
⅝ " laid	48	1,124	109	2,502	138	3,648	469	10,507	436	10,365	286	6,366	82	1,845	1,568	36,357
⅝ " abandoned	137	2,913	13	221	23	459	29	732	27	529	13	221	4	250	246	5,325
½ " "	3	54	11	193	6	202	59	660	3	71	1	15	....	....	83	1,195
Total laid	222	5,433	117	2,779	151	3,915	557	13,227	449	10,746	307	7,294	86	1,999	1,889	45,393
" abandoned	165	3,426	26	500	30	667	102	1,710	34	667	14	236	6	306	377	7,512
Net increase	57	2,007	91	2,279	121	3,248	455	11,517	415	10,079	293	7,058	80	1,693	1,512	37,881

Meters in Service, January 31, 1894.

Cochituate.	Diameter in Inches.								Total.
	6	4	3	2	1½	1	¾	⅝	
Worthington	2	10	22	118	103	542	418	69	1,284
Crown	2	22	35	43	105	237	323	1,199	1,966
B. W. W.	...	...	...	...	...	...	148	....	148
Hersey	...	1	5	12	20	39	87	21	185
Metropolitan	...	...	...	...	...	78	361	4	443
Ball & Fitts	...	...	...	...	...	...	3	4	7
Thomson	...	...	...	1	...	1	....	6	8
Desper	...	...	...	...	...	...	2	2	4
Nash	...	...	...	...	...	...	....	1	1
	4	33	62	174	228	897	1,342	1,306	4,046

Meters Purchased.

Cochituate.	Diameter in Inches.								Totals.
	6	4	3	2	1½	1	¾	⅝	
Crown	...	...	6	5	26	25	75	....	137
Gem	...	1	...	...	...	...	....	....	1
Hersey	...	1	...	...	...	1	13	....	15
Metropolitan	...	...	...	...	...	30	135	....	165
Worthington	1	...	3	4	6	...	....	....	14
	1	2	9	9	32	56	223	....	332

Meters Sent to Factory for Repairs.

Cochituate.	Diameter in Inches.						Total.
	3	2	1½	1	¾	⅝	
Crown	...	1	2	21	12	106	142
Hersey	...	1	1	1	1	1	5
Worthington	1	4	3	32	1	....	41
	1	6	6	54	14	107	188

Meters Applied.

COCHITUATE.	Diameter in Inches.								Total.
	6	4	3	2	1½	1	¾	⅝	
Crown	...	4	3	6	20	19	36	49	137
Hersey	...	...	...	3	1	2	12	...	18
Worthington	1	2	2	6	7	25	5	6	54
B. W. W.	...	...	...	...	...	...	2	...	2
Metropolitan	...	...	...	...	...	10	25	...	35
Ball & Fitts	...	...	...	1	...	...	1	...	2
	1	6	5	16	28	56	81	55	248

Meters Discontinued.

COCHITUATE.	Diameter in Inches.							Total.
	4	3	2	1½	1	¾	⅝	
B. W. W.	...	...	...	...	...	8	...	8
Ball & Fitts	...	...	1	...	...	...	...	1
Crown	1	2	...	5	6	8	29	51
Am. Frost	...	...	...	...	...	1	...	1
Hersey	...	...	2	2	...	3	...	7
Metropolitan	...	...	...	...	1	8	...	9
Worthington	2	3	5	3	14	5	1	33
	3	5	8	10	21	33	30	110

Meters in Service, January 31, 1894.

MYSTIC.	Diameter in Inches.								Total.
	6	4	3	2	1½	1	¾	⅝	
Ball & Fitts	...	...	2	...	...	...	...	...	2
Crown	2	7	8	12	2	33	44	101	209
Hersey	...	1	1	3	1	8	...	...	14
Metropolitan	...	...	...	...	...	13	29	...	42
Worthington	...	11	6	42	7	71	51	6	194
	2	19	17	57	10	125	124	107	461

Meters Applied.

Mystic.	Diameter in Inches.						Total.
	4	3	2	1	$\frac{3}{4}$	$\frac{5}{8}$	
Crown	1	1	1	2	3	11	19
Hersey	...	2	1	3	..	...	6
Metropolitan	...	...	...	4	10	...	14
Worthington	...	...	6	1	...	...	7
	1	3	8	10	13	11	46

Meters Discontinued.

Mystic.	Diameter in Inches.						Total.
	4	3	2	1	$\frac{3}{4}$	$\frac{5}{8}$	
Crown	1	1	1	1	2	9	15
Hersey	...	...	...	2	...	...	2
Metropolitan	...	...	...	...	1	1	2
Worthington	...	...	...	...	1	...	1
	1	1	1	3	4	10	20

Meters Sent to Factory for Repairs.

Mystic.	Diameter in Inches.						Total.
	6	4	2	1	$\frac{3}{4}$	$\frac{5}{8}$	
Crown	1	1	...	2	4	20	28
Worthington	...	...	2	...	3	...	5
	1	1	2	2	7	20	33

Meters Repaired in Service.

CAUSE.	Cochituate.	Mystic.
Leak at coupling	45	10
" spindle	78	5
" stop-cock	5	
Not registering	45	10
Clock broken	57	14
" defaced	32	6
Ratchet broken	6	5
Spindle stuck	2	
Stopped by fish	....	3
" sand	....	4
	270	57

Meters Changed.

CAUSE.	Cochituate.	Mystic.
For test	570	34
Not registering	214	65
Unsatisfactory	34	7
Frozen	29	1
Enlargement of service	25	4
No force	100	11
Leak at coupling	16	
" body	24	3
" spindle	18	
Clock broken	31	2
" defaced	11	2
Service reduced	....	1
	1,072	130

General Statement of Meters for Year ending January 31, 1894.

	Cochituate.		Mystic.	
	Meters.	Boxes.	Meters.	Boxes.
In service, January 31, 1894	4,046	......	461	
New set	248	46	46	14
Discontinued	110	......	20	
Changed	1,072	......	57	
Changed location	22	......	1	
Tested at shop	2,192	......	202	
Repaired at shop	503	......	56	
Repaired at factory	188	......	33	
Repaired in service	270	34	57	27
Purchased	332			
Lost in service	4			

Hydrants Established and Abandoned during the Year.

	Established.				Total.	Abandoned.				Total.	Increase.
	Lowry.	Post.	B. Lowry.	Boston.		Lowry.	Post.	B. Lowry.	Boston.		
Boston	20	20	2	..	42	2	1	4	8	15	27
South Boston	4	6	2	..	12	1	..	1	3	5	7
Roxbury	2	32	2	4	40	6	..	4	6	16	24
Dorchester	3	61	6	..	70	2	1	9	5	17	53
West Roxbury	4	54	13	..	71	1	..	6	2	9	62
Brighton	2	14	4	..	20	..	1	4	..	5	15
Rainsford Island	..	..	...	1	1	..	..	...	..	..	1
	35	187	29	5	256	12	3	28	24	67	189

Total Number of Hydrants in Use, January 31, 1894.

	Lowry.	Post.	B. Lowry.	Boston Y.	Boston.	Total.
Bostou	691	246	66	....	510	1,513
South Boston	214	93	21	1	259	588
East Boston	138	84	24	....	138	384
Roxbury	663	195	63	....	95	1,016
Dorchester	575	423	184	....	67	1,249
West Roxbury	122	468	166	....	48	804
Brighton	79	269	59	....	36	443
Deer Island	....	16	....	....	....	16
Brookline	5	....	....	....	3	8
Chelsea	....	....	....	....	7	7
Quincy	....	7	....	....	....	7
Long Island	....	4	....	....	....	4
Thompson's Island	....	2	....	....	....	2
Rainsford Island	....	....	....	....	1	1
	2,487	1,807	583	1	1,164	6,042

Water-Posts.

DISTRICT.	Put in during the year.	Abandoned during the year.	Number now in service.
Boston	3	....	45
East Boston	5	....	28
South Boston	2	....	27
Roxbury	6	2	64
Dorchester	3	....	75
West Roxbury	2	....	61
Brighton	3	1	41
	24	3	341

Hydrant barrels changed for repairs	219
Hydrant boxes renewed	178
Stop-cock boxes renewed	243
Dead ends blown off	122
Water-posts repaired	211
Fountains repaired	48
Hydrants cleaned and oiled	253

Repairs of Pipes during the Year ending Jan. 31, 1894.

	Diameter of Pipes in Inches.																			Total.
	48	36	30	24	20	16	12	10	8	6	4	3	2	$1\frac{1}{2}$	$1\frac{1}{4}$	1	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{1}{2}$	
Boston	.	3	15	8	10	36	11	.	8	76	38	12	7	5	2	18	7	567	9	832
South Boston	.	.	.	.	1	.	3		1	12	1	.	1	1	.	1	1	150	14	186
East Boston	.	.	.	.	7	.	4	.	.	2	5	.	.	1	.	3	.	141	5	168
Roxbury	1	1	.	1	.	1	14	1	1	15	10	1	4	1	.	8	7	273	26	365
Dorchester	.	.	.	.	.	.	5	.	4	8	.	.	.	.	.	.	1	188	4	210
West Roxbury	.	.	.	1	.	.	7	.	3	3	.	2	.	.	.	.	2	64	.	82
Brighton	.	.	.	.	.	.	2	.	.	4	.	.	.	.	.	.	.	29	.	35
Long Island	.	.	.	.	.	.	.	.	.	3	.		.	.	.	.	.	. . .	.	3
Chelsea	.	.	.	1	.	.	.	.	.	. .	.	.	.	.	.	.	.	. . .	.	1
	1	4	15	11	18	37	46	1	17	123	54	15	12	8	2	30	18	1,412	58	1,882

Causes of repairs that have occurred in 4 inches diameter and upwards:

Settling of earth	18	
Blasting	4	
Defective joints	141	
" pipes	21	
" stop-cocks	20	
" packing	78	
" stuffing-box	4	
Cap blown off.	3	
Frozen	6	
Falling wall (fire)	2	
Changed location	21	
Eaten by soil	1	
Broken by gas men	1	
" sewer men	3	
Pierced by pipe	1	
" drill	1	
" pick	2	
	—	327

Of 3-inch and in service-pipes:

Settling of earth	260	
" service-box	3	
Broken by gas men	1	
Carried forward,	264	327

Brought forward,	264	327
Broken in sewer-trench	14	
" by sewer men	13	
" " Tel. Co.	1	
Gnawed by rats	4	
Eaten by soil	18	
Broken by blasting	8	
Eaten by ashes	1	
Broken by pile-driver	1	
Struck by pick	79	
Pierced by drill	1	
Changed grade of street	15	
" location	23	
Uprights in way of edgestone . . .	238	
In way of manhole	3	
Defective joints	31	
" packing	16	
" coupling	28	
Broken by steam-roller	4	
Defective stop-cocks	40	
" church-cocks	6	
" pipe	97	
Nail-hole in pipe	1	
Dead pipe	7	
Defective plug	2	
Building demolished	1	
Stoppages by dirt	40	
" gasket	7	
" solder	3	
" fish	49	
" rust	417	
" frost	120	
Broken by plumbers	3	
		1,555
		1,882

In addition to the above, 363 service-pipes were shut off for repairs inside street line, and notice of the same sent to the On and Off Division of the Income Department.

Statement of Leaks and Stoppages from 1850 to 1893.

Year.	Diameter in Inches.		Total.
	Four inches and upwards.	Less than four inches.	
1850	32	72	104
1851	64	173	237
1852	82	241	323
1853	85	260	345
1854	74	280	354
1855	75	219	294
1856	75	232	307
1857	85	278	363
1858	77	334	401
1859	82	449	531
1860	134	458	592
1861	109	399	508
1862	117	373	490
1863	97	397	494
1864	95	394	489
1865	111	496	607
1866	139	536	675
1867	122	487	609
1868	82	449	531
1869	82	407	489
1870	157	707	864
1871	185	1,380	1,565
1872	188	1,459	1,647
1873	153	1,076	1,229
1874	434	2,120	2,554
1875	203	725	928
1876	214	734	948
1877	109	801	910
1878	213	1,024	1,237
1879	211	995	1,206
1880	135	929	1,064
1881	145	883	1,028
1882	170	1,248	1,418
1883	171	782	953
1884	253	1,127	1,380
1885	111	638	749

Statement of Leaks and Stoppages from 1850 to 1893.— *Concluded.*

YEAR.	DIAMETER IN INCHES.		Total.
	Four inches and upwards.	Less than four inches.	
1886	150	725	875
1887	172	869	1,041
1888	216	1,140	1,356
1889	183	849	1,032
1890	180	718	898
1891	194	758	952
1892	212	1,232	1,444
1893	327	1,555	1,882

Respectfully,

WILLIAM J. WELCH,
Superintendent.

REPORT OF THE RESIDENT ENGINEER AND SUPERINTENDENT OF THE WESTERN DIVISION.

South Framingham, January 1, 1894.

Thomas F. Doherty, Esq.,

Chairman Boston Water Board:

Sir: The annual report for the Western Division of the Boston Water-Works is submitted herewith.

Sudbury-River Basins.

Water-shed, 75.2 square miles.

The rainfall for 1893 was 48.9 inches at Framingham, and the mean rainfall taken at Framingham and Dam 4 was 48.18 inches, which is about the average rainfall. The quantity of water proved just enough to carry the city through the year without any restriction in the consumption, but with little margin. Late in the summer, as the level of Lake Cochituate began to approach the top of the aqueduct, some alarm was naturally felt in regard to the abundance of the supply, and temporary pumps were erected.

Basin 4 was drained entirely dry during the summer.

The construction of Basin 6 has been completed sufficiently to allow the basin to be filled, and the gates will probably be closed in a few days.

A large amount of work has been done during the year on questions connected with the construction of another Basin, No. 5, to be built at Nichols' Mill site on Stony brook. Early in the year plans were made for the dam and a contract awarded for its construction. When built this basin will be the largest ever undertaken by the city. Its capacity will be 7,438,000,000 gallons. It will cover about 1,500 acres, will be 70 feet deep at the lower end, and will add at least 15,000,000 gallons to the supply in the driest year.

The dam will be 80 feet high at the highest point and 2,000 feet long. The greater part of this season has been occupied in arriving at an agreement with the town of Southboro' in regard to the plans for the roads affected by the proposed basin. On June 29 the first conference was held with the County Commissioners of Worcester County, and since that time a number of public hearings have been held and negotiations have been carried on between the Water

Board of Boston and a committee of citizens from Southboro'. An agreement has been practically reached, but not yet signed. Work will probably be begun early in the coming season.

The color of the water in Boston has been increasing somewhat during the past two years, for the following reasons: The increase in storage at the sources of supply does not keep up exactly with the increase of consumption in the city. When a new basin is completed the storage suddenly receives a large addition and then remains for several years without any increase until the growing demands of the city call for the building of more works. Before another basin is built the resources of the system are taxed to their utmost to supply sufficient water, and the basins are perhaps drawn down to their lowest levels. It is well known that where reservoirs are properly built the quality of the surface water stored in them improves the longer it is kept in store; but this process requires that the basin should be tolerably full; for where it is drawn down to the natural bed of the stream, the water simply passes through it without any improvement whatever. The nearer we get to the limit of our resources, as far as the quantity of water to be supplied is concerned, the less storage we have on hand at the end of the dry period, and consequently the water is sent to the city when the winter flows first begin, with but little benefits derived from storage. This leads me to the conclusion that in order to deliver water of approximately uniform quality, the storage supplied should not only be sufficient to cover the periods of drought, but should also be sufficient to supply stored water for a somewhat longer period.

No excessive growths of algæ have visited the basins, and no general or serious complaints of the quality of the water have been made during the past year.

Reference was made in the last annual report to studies for the drainage of Cedar swamp. Much attention has been given to the question whether it would be better to build a basin in the swamp by excavating the mud and raising the water-line, or whether, all things considered, it would be better to reclaim the swamp. Now that it has been decided to build Basin 5 with its enormous storage the question assumes a different aspect. With Basin 5 built, the importance of a basin in Cedar swamp to reinforce the supply becomes less, for the reason that as we rise in the scale of development of a given water-shed the advantages of additional basins diminish, as will be seen by an inspection of the following table, showing the result of giving up any one basin while all the rest remain in service:

	Area of water surface. Acres.	Storage.	Increase to daily supply of city.		
			As successively added.	Proportional to capacity.	Taking each as if last on the list.
Whitehall pond	550	1,257	13.7	4.3	1.5
Basin 1	130	288	2.0	1.0	0.4
Basin 3	230	1,081	4.9	3.7	1.5
Basin 2	120	530	2.2	1.8	0.8
Basin 4	150	1,416	6.3	4.9	2.3
Basin 6	170	1,530	6.0	5.2	2.6
Basin 5	1,000	7,438	15.8	25.5	11.7
Cedar Swamp basin .	500	2,271	3.3	7.8	3.3
Total	2,850	15,811	54.2	54.2	

It therefore seems clear to me that it would be better to proceed at once with the construction of the drainage scheme already perfected. To aid in carrying out this work the following act was passed in 1892:

[CHAPTER 434.]

AN ACT AUTHORIZING CERTAIN IMPROVEMENTS IN THE SUDBURY RIVER IN THE TOWNS OF WESTBORO' AND HOPKINTON.

Be it enacted, etc., as follows:

SECTION 1. For the purpose of protecting and preserving the purity of the water of the Sudbury river, the city of Boston, by the Boston water board, may, wherever said board shall deem necessary within the towns of Westboro' and Hopkinton, from time to time, widen, deepen, and straighten the existing channels of, or make new channels for, the Sudbury river and its tributaries, and may construct ditches connecting with said river or its tributaries, and may, from time to time, repair and maintain the said channels and ditches as now existing, or as so changed, altered, or constructed.

SECT. 2. Said city, from time to time, before constructing any improvement hereinbefore described, shall file in the registries for the districts in which the lands lie, a map or maps, showing thereon as far as practicable the existing channels of said river and its tributaries, the changes or widenings proposed to be made therein, and the locations and sizes of any ditches proposed to be made.

SECT. 3. The said city may by said board, in carrying out the purposes aforesaid, enter upon and dig up any public way or railroad, and conduct any channel of said river or its tributaries, or any ditches across the same, and, in case any channel or ditch passes under any existing bridge, it shall be left by the city in good condition, and if across any highway or railroad a new channel or ditch is constructed, the said city shall compensate the town or railroad corporation for constructing and maintaining a suitable bridge over the same.

SECT. 4. Any person claiming to be injured in property by any act done by said city under the authority of this act, if the said water board acting for said city fails to make satisfactory compensation therefor, may at any time within three years after the said filing of a map or maps by the city petition the superior court for the county of Worcester for a jury to determine the amount of his damages, and thereupon after such notice as the court shall order, a trial shall be had at the bar of said court in the same manner as other cases are tried by jury. In estimating the damages caused by such acts there shall be allowed by way of set-off the benefit, if any, to the property of the petitioner by reason thereof, and interest shall be added from the date of filing his petition as aforesaid; costs shall be taxed and execution issued for the prevailing party as in civil cases.

SECT. 5. If said city, in carrying out the powers aforesaid, does any work or makes any repairs in any public way which is outside its limits, it shall do the work and make the repairs in such manner and with such care as not to render the way unsafe or unnecessarily inconvenient to the public travel thereon, and in accordance with such reasonable regulations as the selectmen of the town in which such way may be located shall prescribe, and shall restore the way to as good order and condition as it was when such work or repairs therein commenced.

SECT. 6. Said city shall at all times indemnify and save harmless any town against all damages and costs which may be recovered against such town, on account of any defect or want of repair in any of the public ways of such town, caused by any act done under the authority of this act or by any negligence of said city and its agents, and shall reimburse to such town all reasonable costs and expenses incurred by it in the defence of suits for such recoveries, provided that said city has notice of any claim or suit for such damages and an opportunity to assume the defence thereof.

SECT. 7. Nothing in this act shall be construed to authorize the city of Boston to interfere with the present water-supply of the town of Westboro', or with the water-shed of said water-supply above the present reservoir dam of such supply.

SECT. 8. This act shall take effect upon its passage.

[*Approved June 16, 1892.*]

Basin 1.

Grades, H. W., 161.00; Tops of Flash-boards, 159.29 and 158.41; Crest of Dam, 157.54. Area, Water Surface, 143 acres; Greatest Depth, 14 ft.; Contents, below 161.00, 376,900,000; below 159.29, 288,400,000 gals.

On January 1, 1893, this basin stood at elevation 157.44 above tide marsh level in Boston, from which all heights are reckoned. Water was wasting at this time over the stone crest, and continued to waste until January 11. The surface then gradually fell to 157.27 on February 6, when it began to rise, and on February 7 flowed over the dam and continued to waste until April 16. On April 14 a waste-gate was opened in order to draw off the basin to make repairs on the 48-in. main. On May 1 the water stood at 147.83, rising to 157.18 on May 5, and falling to 146.97 on May 29. The surface then rose slowly, and on June 6 the waste-gate was shut.

On July 6 the water reached 156.54, and remained at about this level until September 11, after which it fluctuated

between 155.00 and 156.00 for the remainder of the year. No flash-boards have been placed on the dam during the year.

The highest elevation was 159.20 on March 15, and the lowest 146.88 on June 2.

Water was drawn wholly from this basin for the supply of the city from February 10 to April 14, and from December 2 to the end of the year.

For several years past trouble has been experienced with the 48-in. mains in the bottom of this basin, connecting Basins 2 and 3 with the gate-house. These troubles arose from leaks in the pipes. Two of these leaks, one on the Basin 3 branch and one on the Basin 2 branch, were very bad, and limited the quantity of water that could be run through the mains, for if the head was increased the water escaped into Basin 1. During the latter part of May and the first part of June, water was drawn out of the basin and the more dangerous leaks were repaired. This involved digging around the joints. In many cases the lead was found to be loose all around the pipe.

No other repairs of importance have been made. The gate-house is in good condition.

A flow of at least one and one-half millions of gallons has been passed into the river daily in accordance with the law.

Basin 2.

Grades, H. W., 168.00; Tops of Flash-boards, 167.12 and 166.49; Crest of Dam, 165.87. Area, Water Surface, 134 acres; Greatest Depth, 17 ft.; Contents, below 168.00, 568,300,000; below 167.12, 529,860,000 gals.

On January 1, 1893, the surface of the water was at elevation 163.04, and it rose to 164 96 on January 10, from which point it gradually fell to 158.72 on February 7. After this date the water rose rapidly, and on February 11 waste over the stone crest began. This overflow continued until March 8, when the gates having been opened it fell to 160.54 on March 10, but again rose, and on March 23 was flowing over the dam, and so continued until May 27, when both sets of flash-boards and also an additional temporary set were placed in position. The water then rose and was kept at about 167.00 until June 30, when the surface began to fall gradually, reaching 159.65 on August 4, at which time it received water from Basin 4. The water remained between 161.00 and 163.00 until October 7, after which the basin gradually fell to 155.53 on November 28, and then gradually rose with slight fluctuations to 160.00 on December 31. On September 16 all flash-boards were removed. The highest water during the year was 167.23 on June 24, and the lowest, 155.30 on December 1.

Water for the supply of the city was drawn wholly from this basin from May 23 to May 24, and from August 3 to September 26. The supply was drawn partially from this source and from Basin 3 from January 1 to February 10, April 14 to May 21, May 24 to August 3, and from September 26 to December 2.

The following repairs have been made: the upper gates scraped and painted; slope paving near dam extending 125 feet; house and barn on the Le Baron place shingled and repaired; and wooden culvert at upper end of basin replaced by stonework.

Organisms were not abundant during 1893, and those present were found in the summer and autumn. Cyclotella and Synedra among the diatoms, and Raphidium of the Chlorophyceæ, and Miscrocystis of the Cyanophyceæ have been the most important growths. There was a slight growth of Uroglena in October. The amorphous matter has been more abundant than usual, especially in October and November.

The mean temperature of the water has been 51.2° Fahrenheit, based on weekly observations.

The mean color of the water has been 1.00. Last year it was 1.01.

Basin 3.

Grades, H. W., 177.00; Crest of Dam (no flash-boards), 175.24.
Area at 177.00, 253 acres; Contents, below 177.00, 1,224,500,000 gals.
Area at 175.24, 248 acres; Contents, below 175.24, 1,081,500,000 gals.
Greatest Depth, 21 feet.

On January 1, 1893, this basin stood at grade 171.58 and the surface gradually fell to 166.76 on February 7. From this date the water rose, and on February 13 was flowing over the crest of the dam. Waste continued until March 5, when one of the gates was opened, and on March 10 the water had fallen to 169.50, and on March 23 was again wasting, and so continued until June 7. The surface then fell to 167.72 on August 2. It remained at about this level until September 29. On October 25 the water had fallen to 157.81, remaining at about 158.60 until December 4, from which date it rose to 168.20 on December 31. The highest point reached was 176.20 on May 4, and the lowest 157.81 on October 23. No water has been drawn solely from this source: it has been drawn partly from this basin and partly from Basin 2, on dates already given.

The water in Basin 3 has been generally better during the past year than in 1892. The organisms were not as numerous and the chemical results were better. The spring growth of diatoms (Synedra and Tabellaria) was small, and

the autumn growth of Tabellaria and Asterionella was of short duration and not as vigorous as last year. Protococcus was quite abundant during the summer and autumn; so also was Cœlospherium. During October and November Synura was quite abundant, especially at the upper end. It was found that in Nichols' and Rice's mill ponds, just above Basin 3, the Synura was developed in large numbers, frequently reaching 1,000 standard units per c.c. In Basin 3, as in the other basins, the amorphous matter has been higher than usual. The average number of living organisms in Basin 3 water has been 332 per c.c.

The mean temperature of the water, based on weekly observations, has been 50.8° Fahrenheit.

The mean color of the water has been 0.94.

The filter-basins on the brook flowing from Marlboro' have not yet been built. The plans and specifications are ready, and I recommend their construction as soon as the frost is out of the ground. The "takings" along the line of the brook in Marlboro' have not yet been settled. The damages asked are so excessive that it seems probable that in many cases the land will be released back to the original owners. A legislative act to ratify this action will be asked for at the present Leislature.

With the exception of the scraping and painting of the upper gates, no repairs have been made at Basin 3 during the past year.

Basin 4.

Grades, H.W., 215.21; Tops of Flash-boards, 215.21+ and 214.89 +; Crest of Dam, 214.23.
Area, Water Surface, 167 acres; Greatest Depth, 49 feet; Contents, below 215.21, 1,416,400,000 gals.

On January 1, 1893, the surface stood at 194.22, after which the water gradually rose, and on March 23 was flowing over the overfall. On May 27 a set of flash-boards was placed in position and waste ceased. On June 2 the water began to overflow, and on June 5 another set of planks was added, and on June 10 waste began over the second set of planks and continued until June 22, when one set was removed, but again placed in position on June 29. The basin was kept just above elevation 215.60 until August 3, when an outlet gate was opened and water drawn for the supply of the city. On September 26 the water was at 179.44. At this time the gate was closed and the water rose to 181.40, October 27, when the gate was again opened and all the water drawn out of the basin for the supply of the city. It was entirely empty on November 17. On November 27 the gate was shut sufficiently to allow the water to rise high enough to measure the flow through the gate. On December

20 the gate was shut to allow the basin to fill, and on December 31 the water had risen to 178.42.

The highest elevation reached was 215.37 on June 16, and the lowest 169.00, basin empty November 18.

While the basin was empty all the gates were overhauled, scraped, and painted. Some improvements were made to the channel of Cold Spring brook by depositing about 193 cubic yards of gravel on the slopes near the dam. The channel was also gravelled for a distance of 150 feet from the end of the slope paving. The boundary lines to city property along Cold Spring brook have been run out and stone bounds set. The new channel for the brook has been excavated between Stations 13 and 17, and 21+50, and 23.

The water chemically has been of almost exactly the same quality as in 1892. The number of organisms has averaged 87 per c.c.

The heavy draughts made upon this basin during the last two seasons have had a considerable influence on the color. In 1891 the mean color at the gate-house was 0.63; in 1892 it was 0.74, and in 1893 it was 0.93, and this, notwithstanding the fact that in 1892 the mean color of the influent stream was higher than in 1893, 1.43 against 1.19.

The temperature of the water has averaged 50.9° at the surface, 48.3° at mid depth, and 45.6° at the bottom.

There have been few diatoms, mostly Cyclotella; Protococcus was present in June and August, and Raphidium in September and October. Microcystis was somewhat abundant in October.

Basin 6.

Grades, H. W., 295.00; Top of Flash-boards, 295.00; Crest of Dam, 294.00. Estimated Area, 185 acres; Estimated Contents, 1,530,300,000 gals.

This basin has just been completed after five years of work. No water has yet been stored in it.

WHITEHALL POND.

Elevation, H. W., 327.91; Bottom of Gates, 317.78. Area at 327.91, 601 acres; Contents, between 327.91 and 317.78, 1,256,900,000 gals.

On January 1, 1893, the water in this pond stood at 323.04. It gradually rose to 323.30 on January 6, but fell to 322.88 on February 5. It then rose to 324.00 on February 27 and kept at about this level until March 8, after which it rose to 326.00 April 11, and to 327.00 on May 4, remaining at this point until May 17. The surface then fell to 325.17 on August 16. On September 12 the pond stood at 325.00 and on October 22 at 324.43, remaining at about this height until November 27, when it began to rise steadily,

and on December 31 it had reached 324.94. The highest point reached during the year was 327.07, May 4, and the lowest, 322.88, February 4.

Measurements of the yield from this source have been made daily at the weir at the outlet. The gates at the dam have been, as heretofore, under the control of the mill-owners.

Nothing has been done with the dredging plant otherwise than to inspect it daily and to wet down the decks in the hot weather.

Farm Pond.

Grades, H. W., 149.25; Low Water, 146.00.
Area at 149.25, 159 acres; Contents, between 149.25 and 146.00, 165,500,000 gals.

On January 1, 1893, the water of Farm pond stood at 148.63. The water has been kept at about high-water mark during the whole year. The highest elevation reached was 149.92 on May 19, and the lowest, 148.18 on October 22

No water has been drawn from this source for the supply of the city.

The Framingham Water Company have pumped 103,000,000 gallons from the pond, or 282,192 gallons daily. The total amount of water wasted has been 96,400,000 gallons, all of which, with the exception of 4,500,000 gallons, was turned into Sudbury river.

Lake Cochituate.

Grades, H. W., 134.36; Invert of Aqueduct, 121.03; Top of Aqueduct, 127.36.
Area, Water Surface at 134.36, 785 acres.
Contents, between 134.36 and 127.36, 1,515,180,000; between 134.36 and 125.03, 1,910,280,000 gals.
Approximate Contents, between 134.36 and 121.03, 2,447,000,000 gals.; between 134.36 and 117.03, 2,907,000,000 gals.

On January 1, 1893, the surface of the lake stood at 128.41, or 5.95 feet below high water, but it gradually rose to 128.94 on January 9, when flow in aqueduct having been started it fell to 127.34 on February 6. On February 18 it had risen to 129.50, remaining at about this height until March 7, after which it rose to 134.36 on April 21. With slight fluctuations it remained full until May 22, when it began to fall steadily during the summer, reaching 127.73 on October 27. At that date the Dudley pond connection was opened and the stop-planks taken out of the circular dam, which raised the lake to 128.31 on October 28. On November 7 the surface began to fall again, and on December 3 it stood at 127.55. After this it rose slightly, and kept on the average at about 127.60 until December 25, when it began to rise slowly, and on December 31 it stood at 127.93. The amount of water wasted during the year was 255,300,000 gallons.

Advantage was taken of this overflow to make some exper-

iments at the new dam at the outlet for the purpose of obtaining coefficients for the waste-gates and for the openings under the bridge forming the roll-way. The water was passed over a weir 20 feet long, erected for this purpose.

In October the amount of storage on hand, both in the basins of the Sudbury river and in the lake, was so small that it was feared the supply to the city might not be maintained, so two engines were purchased and erected near the gate-house. Pumps were made ready to place on the old platforms in the lake in order to pump up 20,000,000 gallons daily from the lake into the aqueduct; but the water remained at about the right height to keep up the flow without pumping, and the machinery was not used. A different arrangement of the plant was planned from any heretofore used. Both engines were placed together on the northerly side of the gate-house and the plans contemplated belting down to the pumps, which were to be located on platforms and placed one behind the other with long shafts, terminating in pulleys at convenient points for the belts. On December 20 work on this machinery ceased, it having been partially tested, housed, and put in perfect readiness for operation.

The water in the lake has been very satisfactory in quality. In January Asterionella and Stephanodiscus were quite abundant. In February and March the organisms were few. In April we had the usual spring growth of diatoms, Melosira, Asterionella, and Stephanodiscus appeared successively. By July they had practically disappeared. In November, after the turning over, Tabellaria and Melosira developed again, but the autumn growth was not so extensive as usual. Chlorophyceæ were present in small numbers from June to November. Microcystis appeared in June and increased gradually until September. During September and October it was quite abundant. Clathrocystis was present in October. From November 1 to the end of the year the Cyanophyceæ decreased. Infusoria were present during the summer at all times, but not abundant. Crenothrix was found in March, April, July, and August. The amorphous matter was more abundant than during 1892, especially in October, November, and December.

The period of stagnation extended from April 18 to November 21. The maximum color at the bottom was 2.00 and the mean temperature 45.0° Fahrenheit at the bottom during this period. The mean color of the surface of Lake Cochituate has been 0.23 during the year, and at mid depth 0.25.

Some negotiations were entered into by your Board with

the Sewerage Committee of Natick early in January, but nothing has come of them, and the town has taken no further action so far as I can learn. The necessity for the expenditure of a large amount of money on the part of the city of Boston towards the construction of sewers in Natick is not as great as it was before the filter-beds were built. The plan submitted by the town was to run a force main, conveying all its sewage across the willow bridge. In case of a break on this line all the sewage would be discharged into the lake.

Filter-Beds.

Probably the first filter-beds ever constructed for the filtration of a feeder to a lake by means of a natural filter-bed were designed in the early part of 1893, and let by contract on May 1 to Auguste Saucier. The prices per cubic yard were, earth excavation 22 cents, rubble-stone masonry $5, concrete $6, and riprap $1.08 per square yard.

The amount of Saucier's contract was . . .	$5,013 69
Day labor on completing works	4,568 16
Supplies, drains, carpenter-work, etc. . .	1,553 88
Engineering	1,449 38
Total	$12,585 11

The above was the cost of construction, exclusive of land damages, which have not yet been settled.

Although all the drains that can be found in Natick have been taken out of the brook, these filters were constructed as an additional safeguard to the water of the lake. It is not intended to take all the water, particularly of freshet flows, upon the beds, but with the exception of a few days in the year the whole flow can be handled by the pumps.

The principal features of the scheme besides the filter-beds are a dam across the brook at its outlet and pumps to lift the water intercepted by the dam onto the beds.

The filter-beds are on the south side of Pegan brook, near its mouth, and extend from the Boston & Albany Railroad to the brook and the lake. They were constructed by removing the soil and putting it into embankments 5 feet high around and between the beds. The latter were formed by simply levelling the sand. There are three beds at elevations 140, 144, and 146.8 above water-works datum, 134.36 being the elevation of high water in the lake. The areas of the beds are about 2 acres, $\frac{3}{4}$ of an acre and $1\frac{1}{4}$ acres respectively. The material of the beds to a depth of 8 feet or so is mostly sand, about as fine as is used for making

Natick Filter-Beds. Analyses of Applied Water, Thomas M. Drown, M.D.

PARTS IN 100,000.

LOCALITY.	DATE OF: Collection.	DATE OF: Examination.	Color.	RESIDUE ON EVAPORATION: Total.	RESIDUE ON EVAPORATION: Loss on Ignition.	RESIDUE ON EVAPORATION: Fixed.	Chlorine.	NITROGEN: ALBUMINOID AMMONIA. Unfiltered.	NITROGEN: Free Ammonia.	NITROGEN: As Nitrites.	NITROGEN: As Nitrates.	Oxygen Consumed.	Hardness.	Iron.	Organisms.	Amorphous Matter.	Bacteria.	REMARKS.
Pegan Brook	1893. July 20	1893. July 20	.10	29.50	10 10	19.40	8.10	.0170	.3600	.0090	.3300	.31	7.86	. .	138	1090	50.0	
" "	" 27	" 28	.14	32.30	8.90	23.40	7.58	.0280	3040	.0140	.4250	.36	8.00					
Applied Water	" 20	" 20	.30	20.40	5.90	14.50	3.60	.0526	.1440	.0140	.2000	.70	4.86	. . .	32	3460	2000	
" "	9.30 A M. " 27	" 28	.43	30.90	9.00	21.90	6.08	.0280	.3136	.0180	.1500	.37	8.29	.	509	280	1600	
" "	9 A.M. August 11	August 12	.70	23.90	7.00	16.90	4.65	.0180	.2380	.0210	.5000	.46	7.21	.03				
" "	September 8	September 9	.60	29.60	8.50	21.10	4.65	.0490	.1600	.0140	.5000	1.14	7.29	.	. . .	1009	8776	
" "	November 17	. . . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .	1075	
Means of 4 Analyses "Applied Water"	. . . .	. . . .	.46	26.20	7.60	18.60	4.75	.0369	.2139	.0168	.4125	.67	6.91	. . .	. . .	. .	2690	

Analyses of Filtered Water.

LOCALITY.	Collection.	Examination.	Color.	Total.	Loss on Ignition.	Fixed.	Chlorine.	Unfiltered.	Free Ammonia.	As Nitrites.	As Nitrates.	Oxygen Consumed.	Hardness.	Iron.	Organisms.	Amorphous Matter.	Bacteria.	REMARKS.
Drain No. 3	July 20	July 20	.00	21.90	6.80	15.10	5.35	.0044	.0160	.0400	.4200	.09	5.50	. . .	10	14	20	
" " 4	" 20	" 20	.00	21.00	7.10	13.90	4 85	.0052	.0320	.0800	.3800	.11	5.65	.	13	61	30	
" " 3	" 27	" 28	.01	24.00	8 00	16.00	5.40	.0056	.0122	.0070	.1500	.06	5.71		715	59	22	* Protococcus growing in outlet.
" " 4	" 27	" 28	.00	22.30	8.20	14.10	4.95	.0066	.0091	.0150	.4000	.08	5.55	. .	31	55	23	
" " 4	9.30 A.M. August 11	August 12	.01	17.30	7.30	10.00	4.15	.0011	.0006	.0055	.5250	.06	5.64	.01				
" " 2	9 A.M. September 8	9 A.M. September 9	.00	23.4	8.50	14.90	4 55	.0076	.0032	.0005	6000	.05	5.57	. .	. . .	. .	1000	
" " 5	" 8	" 9	.00	21.7	7.30	13.90	4.65	.0014	.0020	0050	.5500	.05	5.14	. .	. . .	. .	1200	
" " 5	November 17	. . . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .		. . .	. .	10	
Means of filtered water	. . . .	. . . .	.00	21.66	7.67	13.98	4.84	.0050	.0108	.0219	.4750	.07	5.54			.	{ 333 } { 27 }	Omitting September 8.

Note. — July 20. Water has been applied to Bed No. 1 since June 24. Area of bed, 1.14 acres. Average rate, June 24 to July 28, 467,430 gallons per day on bed, or about 374,000 gallons per acre per day. Rate when samples were taken probably about 280,000 gallons per acre per day. Water all applied in about 6 hours each day.

July 27. Water applied to Bed No. 1.

August 11. Water applied to Bed No. 2. Pumps started at 7.30 A.M. Samples taken at 9 A.M. No water pumped on previous day.

September 8. Water applied to Beds Nos. 1 and 3. Samples collected 3½ hours after pump was started. Approximate rate, Drain 2, 78,750 gallons per hour Drain 5, 72,000 gallons per hour.

November 17. Water applied to Bed No. 3.

Crenothrix grows abundantly in Drain No. 1. Conferva grows more or less in channels leading from all the drains.

plaster. Water percolates through it freely, and it is excellent for the purpose of filtration. There are no underdrains beneath the greater portion of the lowest bed, which comprises nearly one-half of the whole filtration area. Underdrains about 100 feet apart and 8 feet deep have been laid beneath the upper beds. They consist of about 1,150 feet of 8-inch vitrified clay pipe, laid with open joints, having canvas wrapped around them. These underdrains, though not necessary for the passage of the water through the ground, enable a part of the effluent water to be got at for examination.

The dam is of earth, about 8 feet in height above the general level of the ground upon which it is built. Under the middle line of the dam 4-inch tongued and grooved sheet piling was driven. Waling pieces were bolted to the sheet piling, and upon this foundation a concrete wall was built. The embankment was made of such gravel or other material as was found on the premises. It was 10 feet wide on top and had slopes of 2 horizontal to 1 vertical. The up-stream slope was paved. A masonry overflow, 10 feet wide, was provided at elevation 139, but stop-planks were put into it, so that the water can be raised much nearer to the top of the dam, which is at elevation 144. The underdrains were laid by day labor, and also the iron pipes, which are laid under the embankments so as to deliver the water of Pegan brook at different places upon any of the beds as desired. The iron pipe, 6, 8, and 12 inches in diameter, has a total length of nearly 1,000 feet, and it is provided with seven gates.

To pump the water on to the beds there is a portable Hoadley engine, made by McLaughlin, of 25-horse power driving two 6-inch centrifugal pumps, which have been set up at the south end of the dam and protected by a wooden shed. The lift is about 9 feet. Pumping began June 24, 1893. It was stopped from September 11 to November 3, while the flow of the brook was so small that it percolated through the ground or evaporated. The amount pumped in a day has varied very much; it may be estimated at about 500,000 gallons. The capacity of each pump is about 1,800,000 gallons per day. A slight deposit has at times accumulated upon the beds, which have been raked over occasionally and kept in good condition. Chemical and biological examinations of the water of the brook as it goes onto the beds, and of the effluent from the underdrains, have been made from time to time. An inspection of the following table will show the purification obtained by filtration:

DUDLEY POND.

Grades, H. W. 146.46; 18-inch Pipe, 130.36 and 127.36.
Area, Water Surface, 81 acres; Greatest Depth, 27 feet; Contents, above 130.36, 250,000,000 gals.

On January 1, 1893, the water stood at 139.80, 6.65 feet below high water. The water rose to 141.10 on October 28, when the stop-planks were removed and the water drawn off to reinforce the lake. The pond was emptied on November 20, and so remained during the rest of the year.

SUDBURY-RIVER AQUEDUCT.

Grades, 141.352 at Farm Pond; 124.051 at Terminal Gate-House.
Length, 15.89 miles; Size, 7 ft. 8 in. × 9 ft.; Capacity, 109,000,000 gals. 24 hours.

The three portions of this aqueduct are in good condition. The supply and Farm-pond aqueducts were cleaned by machine on May 12 and September 15. The main aqueduct was cleaned by machine between Farm pond and the West Siphon Chamber on May 22 and 23, and by hand from the East Siphon Chamber to Chestnut Hill reservoir on August 21 and 22. The 48-inch pipes in Basin 1 have been flushed out twice during the year. The aqueducts have been in use for 357.66 days, the flow having been stopped for cleaning only. The amount of water carried to the city was 11,737,900,000 gallons, or a daily average of 32,159,000 gallons for the year.

Owing to the scarcity of water in the autumn, the aqueduct was not cleaned, and the usual spring cleaning was prevented on account of the work going on in Newton. No water could be let out at Clark's waste weir.

The only rock that has fallen in the Beacon-street tunnel during the year was 20 pounds at Station 778+06 and 50 pounds at 779+60, in both cases from the roof.

The culverts and other structures have received the usual amount of attention and are all in good condition. In October the culvert in Walnut street, Newton, which takes the surface water from the Sudbury aqueduct and carries it under the Cochituate aqueduct, was rebuilt by the city of Newton under my direction and at the expense of the city of Boston. This work was done to remedy the flooding of Coleman's and O'Connell's land. I have had a full description of all the questions entering into this matter written out and filed in my office, together with a description of the details of the work.

Early in 1893 plans were made for carrying one of the deep sewers of Newton under the Sudbury aqueduct in a quicksand formation in Summer street, Newton Centre. Foreseeing that this would endanger the stability of so large an aque-

duct, I determined to support it upon piles before beginning the excavation. Work of pile-driving was begun on April 24, and the work was safely finished and backfilled on June 21. Twenty-five piles were driven adjoining the aqueduct. The bents were 6 feet apart on centres, lengthwise of the aqueduct. The piles nearest to the structure were only 16 inches from the side walls. All the piles were sunk by means of a water-jet and a 1,170-pound hammer. The pipe for jet was $1\frac{1}{2}$ inch diameter, stapled onto the side of the pile. The piles were driven through $23\frac{1}{2}$ feet of quicksand. The footing of the piles was 11 feet below the bottom of the sewer trench and 35 feet below the street level. The wisdom of driving the piles so deep was shown when the pumps for the sewer work were put in operation. Settlements and cracks occurred in the neighborhood, but the aqueduct remained firmly supported and the flow was not shut off for a single day. The caps on tops of the piles were doubled and a 6-inch space allowed for wedging up to the concrete bed forming the bottom of the aqueduct. The span between the piles at right angles to the aqueduct was $16\frac{1}{2}$ feet. The wedges were driven so as to deflect the timbers in the centre $\frac{1}{2}$ inch, which was the calculated amount they would deflect under the distributed load. Concrete foundations with brick piers were carried up from the sewer, when built, to the under side of the aqueduct before the temporary work was removed. Owing to the care and supervision shown by the Assistant Superintendent, Mr. J. W. Oldham, this difficult and tedious work was safely carried out without so much as a crack to the masonry of the aqueduct.

The fences that were built along the roads having become decayed, 1,767 feet of new fencing were built at various points during the year. This work was done by the regular aqueduct force.

It is ten years since the concrete walk on Waban bridge was resurfaced, and on August 10 and 11 this work was again undertaken. All the cracks in the concrete were first filled with fine dry sand, jarring the surface of the concrete with light blows to compact the sand. A ridge of sand was then formed on each side of the bridge, and a coat of boiling tar, which had been boiled for two hours previously and then reboiled at the time of application, was then passed over the walk as hot as it was possible to put it on. This first coat was sanded, scraped, and swept, and a second coat of tar put on, sanded, scraped, and swept as before, and lastly, a coat of sand was put on to remain.

When the aqueduct was built, the owners of adjoining land were anxious for the privilege of mowing the embank-

ments, and it is needless to say they were allowed to do so, but as the work is difficult, they have nearly all given it up, so that we are now obliged to mow the whole line in order to prevent weeds and briars from killing out the grass.

Cochituate Aqueduct.

Grades, 121.03 at Lake; 116.77 at Brookline Reservoir.
Length, 14.60 miles; Size, 5 ft. × 6 ft. 4 in.; Capacity, 20,000,000 gals. per 24 hours.

This aqueduct has been in service, with the exception of the first eight days in January, during the entire year. The flow was stopped for these eight days to build a sewer under the aqueduct for the city of Newton. A depth of 6.5 feet of water has been maintained in the aqueduct excepting from February 2 to February 8, when the lake was not high enough to furnish this flow. The aqueduct has not been cleaned. In the spring the cleaning was prevented by the work in Newton, and in the autumn by the scarcity of water.

The structures along the line are all in good order and the bushes have been mowed. The work of building the arch at Hammond's brook near Pleasant street, Newton Centre, which was in progress on January 1, 1893, was completed on January 21. The excavation was 18 feet wide and 26 feet deep from the top of the embankment. The material at this point was principally gravel, and the only trouble arose from the shaky conditions of the aqueduct. Beginning at the bottom of the work, there is first a 1-foot sub-drain, over this a brick sewer of egg form 3 feet × 2 feet, and over this an archway for the brook water 10 feet span by 7 feet high, of brickwork. The whole of these structures were encased in concrete where they pass under the aqueduct. The latter was supported by brick piers built upon the masonry underneath.

In November an arrangement was made with the city of Newton by which the city of Boston agreed to allow the construction of a portion of a boulevard, proposed on the part of Newton, upon and over the Cochituate aqueduct in Newton Centre, west of Grant avenue. The city of Newton agrees to take up the tracks of the electric or other railways whenever required, and to bear all extra expense that may arise in the future to the city of Boston by reason of said boulevard, either in maintaining or repairing the aqueduct.

Staurastrum (Desmidieæ) x 570.

Cosmarium (Desmidieæ) x 285.

CHESTNUT HILL RESERVOIR.

H. W., 125.00; Dam, 128.00; Effluent pipes, 99.80.
Area, Lawrence Basin, 37.5 acres; Contents, 166,000,000 gals.; Bradley Basin, 87.5 acres; Contents, 391,000,000 gals.
Total Contents above grade 100.00, 557,000,000 gals.

There has been very little work done at this reservoir during the past year except in the way of maintenance.

A pipe line was laid on South street, running across the grounds and terminating on the driveway with a watering-cart hydrant. This greatly facilitates the work of watering the driveway.

A section of Beacon street was repaired by the Street Department.

The grounds and structures are in excellent condition.

BROOKLINE RESERVOIR.

H. W., 125.00; Area, 23 acres; Greatest Depth, 24 feet; Contents, 119,583,960 gals.

Everything in connection with the Brookline reservoir is in good order. No work other than that pertaining to maintenance has been done on this reservoir during the year.

FISHER HILL RESERVOIR.

H. W., 241.00; Pipe Inverts, 220.00; Depth, 21 feet; Contents, 15,400,000 gals. above 223.

The reservoir is in good condition. In October a soft and springy spot appeared in the embankment a few feet south of the gate-house and on the berm. A deep excavation was made in the walk and the puddle backfilled and rammed solid. No hole was found, but the puddle was not very good.

The grounds have been maintained as usual by the force at Chestnut Hill reservoir.

BIOLOGICAL LABORATORY.

This laboratory has turned out excellent work throughout the year, and proved a valuable adjunct to the proper management of the different sources of supply. Weekly examinations are still made of all the Boston waters and results recorded. Mr. G. C. Whipple is the assistant in charge of all the laboratory work.

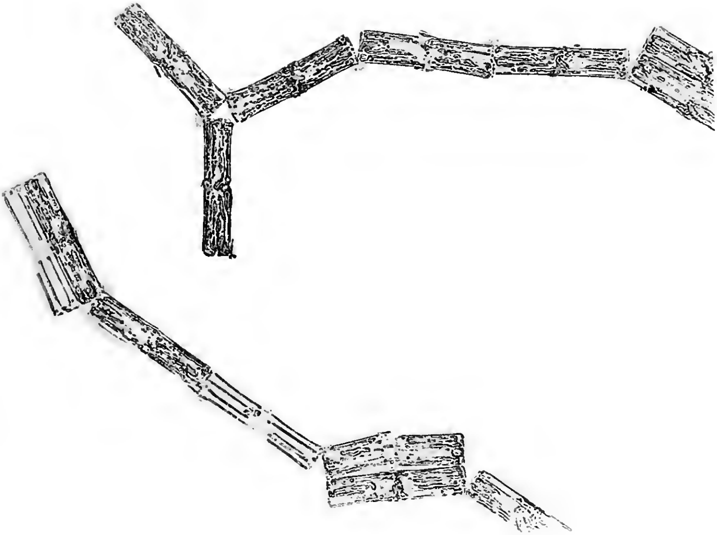
During the year 2,505 microscopical and 1,725 bacteriological examinations have been made in the laboratory. Twenty-five different species of bacteria have been isolated and studied. Investigations have also been made of some of the micro-organisms with regard to their power of producing tastes and odors.

The standard unit referred to in last year's report has been used during the year with satisfactory results. This unit is used in stating the results of the microscopical examinations, and is believed to be an improvement over the old method of giving the results in "number per c.c.," as it takes into account the size of the organisms. The unit is a unit of area, a square, 20 microns on a side (*i.e.*, 400 square microns), and is the same unit which has previously been used in estimating the amorphous matter. A unit of area was selected instead of a unit of volume, on account of the difficulty of using the latter; but if proper judgment is used in estimating organisms which are either very thin or very thick, the unit will have substantially the same value as a unit of volume.

In order to use this unit it is convenient to have the micrometer in the eye-piece divided as follows: The square should first be divided into four equal squares, and each of these quarters subdivided into twenty-five smaller squares, each of which is equivalent to twenty-five standard units. The eye will readily divide the side of the small squares into fifths, and this division will be the side of the square which is the standard unit. The size of the unit is thus continually before the observer. There is little additional labor in applying this unit. Many of the organisms are quite constant in size; these may be counted and then reduced to the standard by multiplying by a previously determined factor. Other organisms are so variable in size that each specimen must be estimated by itself. In case of filaments of constant width, the length may be estimated and a factor applied. These operations can be performed easily and quickly by an experienced observer.

On account of using this unit the results of the past year should not be compared with those of previous years, without making allowance for the different standards. The unit system gives more weight to the summer organisms, *i.e.*, to the Cyanophyceæ and Chlorophyceæ, whose value is underrated by the old method. It has been found that in many cases the curve drawn by plotting the number of "standard units per c.c." corresponds more closely with the curve of the suspended albuminoid ammonia than does the curve of the "number of organisms per c.c." The method also has this advantage, that organisms and amorphous matter are expressed in terms of the same unit.

The study of the color in the Boston water has assumed important proportions, and much time and thought have been given to the subject. The weekly color examinations throughout the system, from the brooks feeding the basins



Tabellaria (Diatomaceæ) x 285.

Clathrocystis (Cyanophyceæ) x 175.

at the sources of supply to the tap water in the city at its centre, and as far out as Mattapan, have now extended over a period of three and one-half years. During the greater part of that time the "Natural Water Standard" has been used, the readings being taken in Nessler tubes holding 50 c.c. and the depth of the water being 200 m.m. Since May, 1893, the colors have been determined by the colorimeter elsewhere described and using the platinum standard, after which they have been reduced by a table to the natural water standard. The results undoubtedly give a fairly good idea of the color in the different seasons.

As has been already stated in my reports, the water acquires its color principally from the swamps on the Sudbury-river water-shed. Some plans have been made for draining the most extensive of these swamps, which it is hoped may be carried out in the near future. In Cedar swamp the color varies from 1.00 to 7.00. In July the color is a rich reddish brown, and in the autumn after the leaves have fallen the color has more of a greenish cast. Indian brook has swamps just above the newly constructed Basin 6, and hence the water flowing into that basin is sure to be highly colored. The color of the water in the swamps on Cold Spring brook at the head of Basin 4 varies from 1.00 to 3.70. There are also swamps on Stony and Angle brooks giving colors of from 1.00 to 3.00. The color of the water in the swamps varies constantly during the year. In the winter the color is naturally low. In the spring we have a high color, reaching its maximum in June. In the summer the swamps are often dry, and though the standing water be highly colored, the flow of the brooks is so small that the effect on the reservoirs is slight. If, however, there are heavy rains during the summer the brooks become highly colored. The observations made on the Boston Water-Works under my direction have been plotted, and I will now give a brief summary of some of the results noted. From a profile of the colors of Cold Spring brook and the amount of water flowing over a weir erected at the head of Basin 4 a general agreement can be traced between the colors and the flow, and the effect of such storms as those in August and September, 1892, are clearly shown. There are two high points found in almost all the studies on the Sudbury-river water-shed, and these occur in the months of June and December, and their influence is felt even in the tap water, for the color is highest in the city in these two months, although the difference is not as marked as in the case of the sources of supply. In the autumn the leaves and decaying vegeta-

tion again cause an increase in the colors of the brook waters.

In Lake Cochituate the two maxima occur in April and November, and the color is much more uniform than the Sudbury throughout the year, and of course much lower. During the winter, when the surface is frozen, the color of the lake-water increases, reaching its maximum in April. During this month the ice has disappeared, and the sun again begins its work of bleaching and the color decreases. In November, when the period of stagnation at the bottom ceases and this highly colored water comes to the surface, we have a second maximum. The profiles of the influents to the lake are based on monthly observations upon four of the principal brooks, and these values are weighted according to the extent of their respective water-sheds. The profiles which have aided graphically in this study of color have consisted of separate lines for each of the years and of lines formed by combining the three years. These have been taken: 1st, for the tap water; 2d, for the effluent gate-house at Chestnut Hill reservoir; 3d, for the Brookline reservoir gate-house; 4th, for the termini of the aqueducts; 5th, by taking the averages of all the basins and then combining them into one line; and 6th, by plotting the averages of all the influent streams at the heads of the basins. The same course has been followed with the Cochituate supply.

Other profiles have been plotted, showing the combined colors for each year at all of the stations. The gradual increase of color is thus brought out, if we except the lake, where there has been a decrease. There is an apparent exception in the case of the influents of Basins 2, 3, and 4, which, however, disappears when the values are weighted by the quantity of water flowing when the observations were made. In the case of Lake Cochituate, the colors at the bottom averaged during the seven months of stagnation as follows: 1.84 in 1891, 1.61 in 1892, and 1.02 in 1893. Exactly why the color has improved, it is difficult to say, but it may be partly on account of the work done in improving the sanitary condition of the brooks, notably Beaver Dam and Pegan brooks.

The increase in color in the basins of the Sudbury supply and in the tap water in Boston is largely due, however, to a very different cause, and one which is brought out graphically on another set of profiles, viz., increased consumption — and in consequence, decreased storage. In a general way, storage reduces the color of water, and the amount of the reduction depends upon the length of time the water is stored, the condition and depth of the basin itself in which the water

is stored, the effect of the seasons (for when the water is covered with ice there is no material improvement in color), and the amount of sunlight existing during the period of storage.

The extent to which the color is reduced in the several basins is shown by the following figures: In 1891, Basin 2 reduced the color of its influent 11 per cent.; in 1892, 8 per cent.; and in 1893, 3 per cent. Basin 3, for the same periods, reduced its influent 23 per cent., 14 per cent., and 0. This effect is clearly due to the heavy draughts made on the storage and the consequent lowering of the water or emptying of the basins. When this is done the water passes through them without change.

Another set of profiles has been made to show the effect of colors of the feeders of a basin when combined with the flow of water. These bring out the great effect of the spring flows on the colors of the waters of the basins at their outlets or at the gate-houses for the whole of the remainder of the year. If the colors of the feeders alone are plotted, there is no correspondence with the profile of colors at the gate-house, but when the product of the color and yield is taken, there is a good agreement. In plain terms, the basins are filled with the whiter water of the melted snows, and the darker water which follows in the summer is not of sufficient quantity to make its effect felt at the outlet ends of the basins.

The four subjects reproduced on the heliotype plates accompanying this report were photographed in the laboratory.

The following description of the Synura uvella, an organism sometimes found in the Boston water, has been prepared by Mr. Whipple:

Of the thirty or more genera of infusoria which are found in the water-supplies of Massachusetts, there are but fifteen which may be said to be commonly found in large numbers. Eight of these common forms belong to one order, and six of them belong to one family of that order, if we adopt the classification of Mr. W. Saville Kent. (See "A Manual of the Infusoria," vol. 1, page 212.)

"This order, Flagellata-Eustomata, includes such of the flagellate infusoria as have an ingestive area constituting a true and distinct mouth, the flagella of the organism not being supplemented by cilia. The special characteristic of the family Chrysomonadidæ is the presence of lateral pigment bands. These color bands, in addition to their distinctive tint, are apparently of firmer consistency than the surrounding transparent protoplasm, and bear a very considerable resemblance to the coloring matter of the Diatomaceæ."

But the most important fact about the Chrysomonadidæ,

from a sanitary point of view, is that almost every one of them has given rise to very disagreeable and sometimes extremely offensive tastes and odors in the waters in which they have been found. Uroglena, Cryptomonas, and Chloromonas have already acquired quite unenviable reputations. To these may be added Synura uvella and Dinobryon. It is noticed also that there is a similarity between the tastes produced by some of the organisms of this group and those produced by certain diatoms. Cryptomonas, for instance, produces a sweetish, aromatic taste, very much like that of the violet. The diatom Asterionella also produces a sweetish, aromatic taste and odor resembling that of a rose geranium, although at times the Asterionella odor is decidedly fishy and oily. Uroglena volvox has a strong oily taste, very much like cod-liver oil. Synura uvella has, at times, a somewhat oily taste, often resembling that of a cucumber, but generally more spicy or bitter. The taste is a very persistent one. "It stays in the mouth." It is strongest at the base of the tongue, where the nerves are most sensitive to bitter substances. The taste of Dinobryon is similar to that of Synura, but is not as strong. In all of the above-mentioned organisms oil-globules have been observed. In some of them the amount of oil has been estimated, and in at least one of them, Uroglena Americana, the oil has been isolated. It remains to be determined if there is any connection between the presence of the pigment bands and the amount of oil production.

It should be stated that these organisms do not always contain oil-globules. In the younger forms they are frequently absent. The oil may be said to be a reserve product, produced by the organism during its growth, and stored up in the cell, — hence it is most common in the older specimens. It is by the disintegration of the cells and the consequent liberation of the oil that the tastes are brought about.

"The Synura animalcules are free-swimming, united in sub-spherical, elongated, social clusters, each zooid contained in a separate membranous sheath or lorica, the posterior extremities of which are confluent. The contained animalcules almost entirely fill the cavities of the loricæ, their posterior extremities being produced towards and adherent to the bottom of the same. The two flagella are sub-equal. Minute eye-like pigment-specks are sometimes present, though generally absent. A large vacuolar space, apparently representing a pharyngeal dilatation, is developed at the anterior extremity. The yellowish-brown color bands are produced equally throughout the length of the two lateral borders. The contractile vesicles are two or three in num-

ber, posteriorly located." (See Kent, loc. cit., vol. 1, page 412.)

The size of the colonies varies from 30 to 75 microns in diameter. Generally there are about twenty zooids in a colony, though sometimes there are as many as forty. The spherical colonies are often seen moving briskly through the water with a rolling motion. The elongated forms generally move more slowly. At a certain stage in its life history, Synura becomes encysted. In this condition it is smaller in size, and the zooids are crowded together and surrounded by a sheath. It is also somewhat darker in color, and is entirely without motion.

Synura in its maturer condition contains oil-globules. They are especially numerous just before encystment.

At times the amount of oil has been approximately determined. On December 9, 1893, a sample from Basin 3 contained 100 colonies of Synura per c.c. It had a strong, bitter taste. Each colony had about 20 zooids, and each zooid contained about 20 oil-globules. The oil-globules had an average size of about one cubic micron. Calculation showed that oil was present approximately in the proportion of one part of oil to 25,000,000 parts of water. This seems to be a very small quantity of oil to produce so strong a taste, but some experiments on a few of the essential oils prove that it is easily within the range of possibility.

The following table shows the degree of dilution at which some of the essential oils can be recognized by taste.

Oil of peppermint	1 : 50,000,000
Oil of cloves	1 : 8,000,000
Oil of checkerberry	1 : 7,000,000
Oil of cassia	1 : 6,250,000
Oil of bergamot	1 : 6,250,000
Cod-liver oil	1 : 1,000,000
Kerosene oil	1 : 800,000

In some cases where dilution was greater than the above figures indicate, the odor was perceptible, but quite different from the real odor of the substance. For instance, kerosene oil diluted 1 : 1,500,000 was described by three persons as smelling "like cologne." This fact may account for the differences in descriptions of tastes and odors produced by the same micro-organism.

Synura is generally found in surface waters where there is a considerable quantity of organic matter. It does not thrive at high temperatures, and is almost always absent from the water during the summer months; or, in other words, it

is almost never found in water having a temperature above 55° F. Only once in the last four years has a growth of Synura been found in Boston water between May and October. The exception was in September, 1891, in Lake Cochituate, where there was a considerable growth at the mid-depth; but even there the temperature was below 55° F. There are, however, rare instances in which Synura has been found in hot weather, as for instance in Walden pond, Lynn, in August, 1891.

In winter the Synura is often found under the ice. Some quite extensive growths have been thus found, as for instance in Lake Cochituate in 1892, and in Basins 3 and 1 in 1893.

While Synura cannot be said to be a very common organism in Boston water, it has frequently been found in Lake Cochituate and Basin 3 during the winter months. In only one or two instances, however, has it been found in numbers sufficient to cause any trouble.

In September, 1891, it was present at the mid-depth of Lake Cochituate, where it imparted a slight taste to the water. Its distribution at this time was something peculiar. The growth was confined to the vicinity of the deep hole near the gate-house, and, moreover, was found only in a stratum about 10 feet thick, about 35 feet below the surface. The temperature of this stratum was between 48° and 50° F. The layer of water immediately below the Synura had a decided cloudiness and contained considerable Crenothrix. These conditions prevailed for about a month, during which the Synura varied from 20 to 70 standard units per c.c. (One standard unit equals 400 square microns.) The following table shows the state of things on September 28, 1891:

Depth in feet.	Color.	Temperature.	Crenothrix per c c.	Synura per c.c.	Cloudiness.	Taste.
35	0.50	49°	0	0	0	0
40	0.55	48°	10	25	Slight	Slight
45	0.95	45°	156	0	Distinct	0
50	2.40	44°	32	0	0	0

In January and February, 1892, Synura was again present in Lake Cochituate immediately under the ice. While the numbers were not large, the conditions for the production of oil were probably at their best, for the taste was strong. This taste and the Synura themselves could be traced through Chestnut Hill reservoir into the service-pipes, where in certain parts of the city the taste was quite strong, and complaints were made by the consumers. It is likely,

however, that other infusoria than Synura helped in the production of this taste. That the taste was not due to the decay of the organisms in the pipes is shown by the fact that the bacteria at that time were quite low, the average of 14 tap samples being only 61 per c.c.

The most extensive growth of Synura which has been found in Boston water occurred in the ponds on Stony brook just above basin 3 in November and December, 1893. Both in Rice's and in Nichols' mill ponds the number of colonies frequently reached 200 per c.c. (equal to about 1,000 standard units). These were gradually washed down into Basin 3. At one time 2,000 standard units were found in the influent stream. They soon became numerous in Basin 3 and in Basin 1. They were present in the Sudbury gate-house at the Chestnut Hill reservoir, in almost every sample during November and December. A few were seen in the effluent gate-house, and even in the service taps, but not in numbers sufficient to impart much of a taste to the water.

There is no question but that the Synura uvella is a very objectionable organism. Mr. F. F. Forbes, Superintendent of Brookline Water-Works, has stated that 10 colonies per c.c. will render a water unfit to drink. From our experience it is certain that 10 colonies of Synura per c.c., if they are in the right condition, will cause a taste sure to be noticed by the consumers.

INSPECTION OF WATER SOURCES.

The following is a digest of the report of Mr. J. S. Concannon, Chief Inspector:

Total number of cases inspected	941
Old cases	836
New	105

Of the above, 368 are reported as remedied, 387 safe at present, 40 seem safe, 41 suspected, 105 unsatisfactory. Thirty-five legal notices were sent.

No legal injunctions were found necessary during the year.

FILTRATION EXPERIMENTS.

Filtration experiments were continued during the year with six large tanks one one-thousandth of an acre in area, and four small tanks one forty-thousandth of an acre in area. Of the six large tanks, four were used for experiments on continuous sand filtration, one for intermittent sand filtration from March to December, and the remainder of the year for

continuous sand filtration; the remaining tank for experiments with dried alumina. All of these tanks were run at rate of 1,500,000 gallons per acre per day. The four small tanks were used for experiments with dried alumina and bone charcoal at rates of flow of from 1,000,000 to 5,000,000 gallons per acre per day.

Analyses of the applied water and the effluents from all of the tanks were made each week during the year. Mr. William E. Foss is the assistant in charge of these experiments. The following description of the investigations into the matter of color has been prepared with the assistance of Mr. Foss.

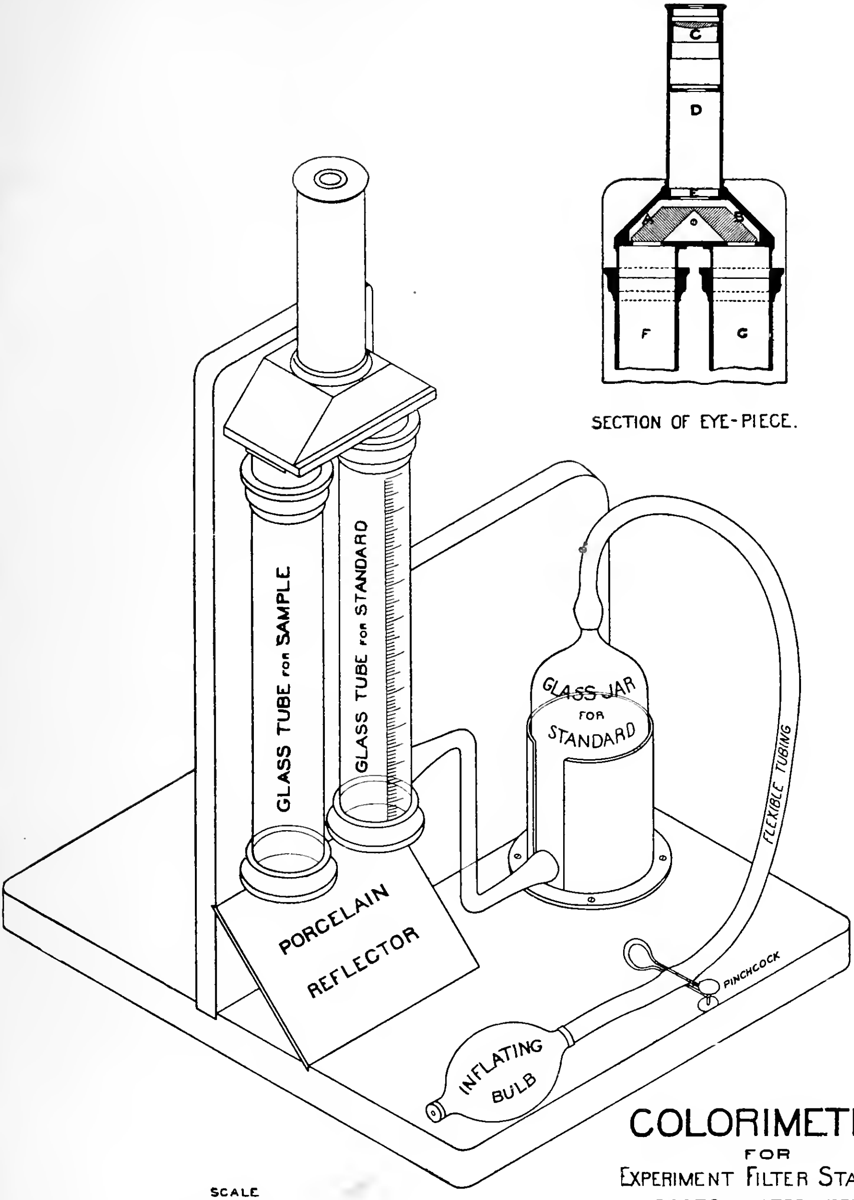
As the color of the Boston water indicates, to a large extent, the quantity of organic matter which it contains, much attention has been given to finding a correct scale to indicate the color.

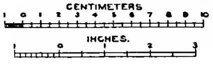
Solar light is a mixture of many component colors, from the violet and blue, through the greens and yellows, to the red.

When solar light is transmitted through a water containing foreign matter, some of its components are wholly or partially absorbed and the transmitted light is more or less colored in consequence. The color depends on the nature of the missing rays, or is the resultant of the rays which have been transmitted. The greater the depth of the water through which the light is transmitted, the greater will be the effect on the components, and the more marked the color.

Light which has traversed a depth of two meters of distilled water has only a very slight blue color; hence it can be said that in pure water all of the component colors are transmitted with almost equal facility.

In order that any change in the color of a water from a given source can be detected, and that the colors of waters from different sources can be compared, color standards are employed. The standards at first used at the filter station were prepared by diluting a highly colored water with distilled water until the colors matched those produced by nesslerizing varying amounts of an ammonia solution (0.01 Mg NH_3 per c.c.) in 50 c.c. of distilled water; the color being recorded as the number of cubic centimeters of the ammonia solution used. These water standards are, therefore, as near as possible, duplicates of the nesslerized ammonia standards employed for reading the color of water. They are much more convenient to use, because their color does not change as rapidly as that of the nesslerized ammonia solutions, which have to be mixed fresh at every observation. A set of standards having been prepared in this manner, the color of





COLORIMETER

FOR

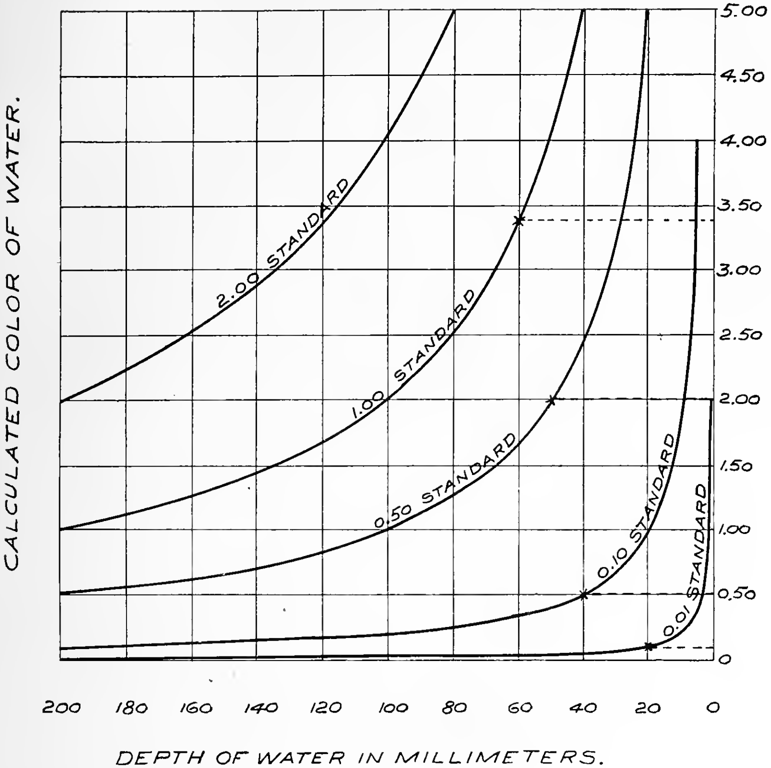
EXPERIMENT FILTER STATION

BOSTON WATER WORKS

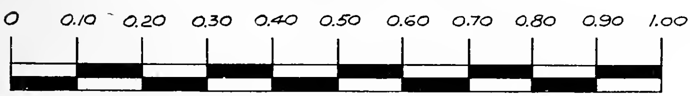
WESTERN DIVISION.

AUG. 1892.

PLATE 2.



UNIFORM SCALE.



NATURAL WATER OR NESSLERIZED-AMMONIA SCALES.

a water is determined in Nessler tubes, which are of glass, about 15 to 20 millimeters in diameter and 300 millimeters in length and closed at one end. The tubes are filled with the different standards, to a depth of 200 millimeters. A similar tube filled to the same depth with the water to be examined is moved along the scale until a point is reached where its color matches that of one of the standards. All of the tubes are viewed against a white background. When the color of the water falls between two consecutive standards, the color is estimated by the observer.

The colorimeter, shown on Plate 1, was designed for reading the colors of waters with greater convenience and accuracy. Plate 1 shows an isometric projection of the complete instrument and a section of the eye-piece. The latter consists of two totally reflecting prisms A and B and a magnifying lens C. The lens is free to slide in the brass tube D, so that it can be focused on the upper faces of the prisms. The field of view is cut down to a circle by a diaphragm E, at the lower end of the tube D.

Rays of solar light from some uniform source, after passing through the water placed in tube F, which has a plate-glass end, enter the prism A, and emerging, illuminate one-half of the circular field of view. Rays of light from the same source, after passing through the standard solution in tube G, enter prism B, and are totally reflected at its surfaces, and emerging illuminate the other half of the field of view. The colors produced by the absorption of the two liquids can then be readily compared and brought to the same value, as follows: The standard solution is held in a glass jar and is connected by means of a glass tube with the standard tube. The top of the jar is furnished with a piece of flexible rubber tubing terminating in an inflating bulb. By means of the latter the observer increases the depth of the standard solution in the standard tube until the color produced on the field of view matches that of the water in the other tube; he then closes the pinch-cock on the tubing and reads the color of the water from the scale on the standard tube.

Before the present form of the colorimeter was finally determined upon, two methods were suggested by which the colors produced by the absorption of the standard solution and the water could be made to match. The first was to vary the depth of the water under examination, while the depth of the standard remained constant. The second was to vary the depth of the standard solution, while the depth of the water remained constant.

A study of the first method showed that the depth of

water could only be varied between certain limits, and that it was better, for accurate results, to keep the water under examination of a definite depth. As the bottom of the tube is approached the change in color, corresponding to any given decrease in depth of water, increases rapidly. It was decided that 200 millimeters would be the most convenient length for the tube, and that the scale divisions should not be less than 2 millimeters to be read accurately; also that a difference in reading of one scale division should not make an error in the resulting color of more than four per cent. It was also assumed for purposes of calculation that the color of the water and standard varied directly with the depth; that is, if the color of a water in a depth of 100 millimeters equals that of the standard in depth of 200 millimeters, then the color of the water would be twice that of the standard. If the color of the water in depth of 20 millimeters equals that of the standard in depth of 200 millimeters, then the color of the water would be ten times that of the standard.

The following table shows the increase of color corresponding to equal variations in depth of the water when a standard of 0.50 is used. It can be seen from the last column of this table how rapidly the differences of color, due to a decrease in depth of 10 scale divisions, increases in the lower portion of the tube. It is thus evident that the readings of color in the upper portion of the tube will be of much greater accuracy than those in the lower portion:

Standard.	Depth of Standard. M.M.	Depth of Water. M.M.	Calculated Color of Water.	Different color for 10 Scale Divisions.
0.50	200	200	0.50	
0.50	200	180	0.55	.05
0.50	200	160	0.69	.07
0.50	200	140	0.71	.09
0.50	200	120	0.83	.12
0.50	200	100	1.00	.17
0.50	200	80	1.25	.25
0.50	200	60	1.67	.42
0.50	200	40	2.50	.83
0.50	200	20	5.00	2.50

In the upper diagram, Plate 2, the colors obtained by calculation have been plotted for several different standards; the abscissas represent the depth of water in the tube and

the ordinates the calculated color when using the standard marked on each curve. The cross on each of the curves shows the point at which the error in a color reading, resulting from an error of one scale division in reading, would equal four per cent. For all waters having colors darker than this, a new standard must be employed.

In this way it was found that where waters having colors ranging from 0. to 1.00 are common, at least three standards are necessary. For quick practical work this method would be very inconvenient.

The second method, however, was found to have none of these objections; it gave readings of equal value in all parts of the tube, and readings from 0. to 1.00 could be obtained with a single standard, as shown by the following table:

Standard.	Depth of Water. M.M.	Depth of Standard. M.M.	Calculated Color of Water.	Different Color for 10 Scale Divisions.
1.00	200	200	1.00	
1.00	200	180	.90	.10
1.00	200	160	.80	.10
1.00	200	140	.70	.10
1.00	200	120	.60	.10
1.00	200	100	.50	.10
1.00	200	80	.40	.10
1.00	200	60	.30	.10
1.00	200	40	.20	.10
1.00	200	20	.10	.10
		0	0	.10

If it were true, as was assumed for these calculations, that the color of the standard varied directly with the depth, then if a depth of 200 millimeters of the 1.00 standard solution gave a color of 1.00 on an adopted scale of color, a depth of 100 millimeters would equal a color of 0.50 on the same scale.

It was known before the instrument was constructed that this would not be the case with the nesslerized ammonia standards or the natural water duplicates, but it was thought that a scale could be graduated on the standard tube by filling the sample tube with various Nessler standards 0.10, 0.20, 0.30, . . . 1.00 and marking the points on the standard tube to which it was necessary to fill it with the 1.00 standard to match them. It was not expected, how-

ever, that a scale marked on the tube in this way would be as irregular as it was found to be.

The irregularities of the nesslerized ammonia and natural water scales are illustrated graphically on Plate 2. The upper scale represents a uniform graduation, and the middle one the graduation corresponding to the nesslerized ammonia and natural water scales. It is an average of determinations made by two independent observers with the colorimeter having the 1.00 natural water standard in the jar. The lower scale shows the graduation of the nesslerized ammonia or natural water scales as determined from the average of the observations on 15 sets of natural water standards in Nessler tubes and in colorimeter compared with the platinum standard, which was also used in Nessler tubes and in colorimeter (hereinafter described). The observations were made by three independent observers.

The differences between the two natural water scales are probably due to changes having taken place in the natural water standards, after their comparison with the nesslerized ammonia standards, or to differences arising in the preparation of the nesslerized ammonia standards.

The following experiment showed that the natural water standards are subject to change. A set of the standards kept in the dark from April 16 to May 16, 1892, and then compared with a new set had changed on an average 0.07.

The irregularities of the nesslerized ammonia and natural water scales are due to the method of preparation and not to any cause introduced by varying the depth of the standard; for, by preparing a set of colors by diluting the 1.00 natural water standard with distilled water, and then reading these colors on the colorimeter, having some of the original 1.00 standard in the jar, gave the following uniform readings. They are an average of the readings of two observers:

Dilution of 1.00 Standard.	Reading on Colorimeter.
.10	.095
.20	.21
.30	.295
.40	.405
.50	.52
.60	.60
.80	.80
1.00	1.00

From these investigations it was learned that the nesslerized ammonia and natural water standards were of very little value for accurate color readings.

To illustrate the misleading results obtained by using these standards the following example may be taken. Water having a color of 0.40 on the Nessler scales before filtration was found to have a color of 0.10 after filtration, showing a reduction of 75 per cent. By the uniform scale, however, shown on the diagram, Plate 2, this reduction will be found to be only about 50 per cent.

By the platinum standard, a new color standard recently suggested by Dr. Allen Hazen,[1] "the color of a water is the amount of platinum, in parts per ten thousand, which in acid solution, with so much cobalt as will match the hue, produces an equal color in distilled water." In preparing a set of standards, a standard solution having a color of 5.00 is usually prepared, and from this the lower standards are prepared by dilution with distilled water.

This standard, from the method of its preparation, can be used in the colorimeter with a uniformly graduated scale. It has also been found to keep without change for months if protected from dust.

The color of a water determined by comparison in the colorimeter should differ slightly from the color obtained by comparison in Nessler tubes and using the platinum standard; due to the fact previously mentioned that distilled water has a slight blue color. In the colorimeter the portion of the tube above the standard is not filled with distilled water, while in Nessler tubes it is filled.

The following readings of a set of platinum standards in the colorimeter having the 1.00 platinum standard in the jar, are the average of two sets of readings by independent observers. They show that the maximum error does not exceed 0.02. In cases where greater accuracy is required for water having a low color, a 0.50 standard can be substituted for the 1.00 in the jar.

Platinum Standard.	Colorimeter Reading.
0.10	0.115
0.20	0.22
0.30	0.32
0.40	0.40
0.50	0.50
0.60	0.595
0.70	0.70
0.80	0.80
0.90	0.895
1.00	1.00

[1] Amer. Chem. Journal, Vol. XIV., No. 4.

The platinum standard has now been adopted for use in the Boston filtration experiments.

For converting any former readings on the Nessler or natural water scale to the platinum, the following table can be used. It was prepared from the average of the fifteen observations by three independent observers mentioned on page 84:

TABLE FOR CONVERTING COLORS ON THE NESSLERIZED AMMONIA AND NATURAL WATER SCALES, TO EQUIVALENT VALUES ON THE PLATINUM SCALE.

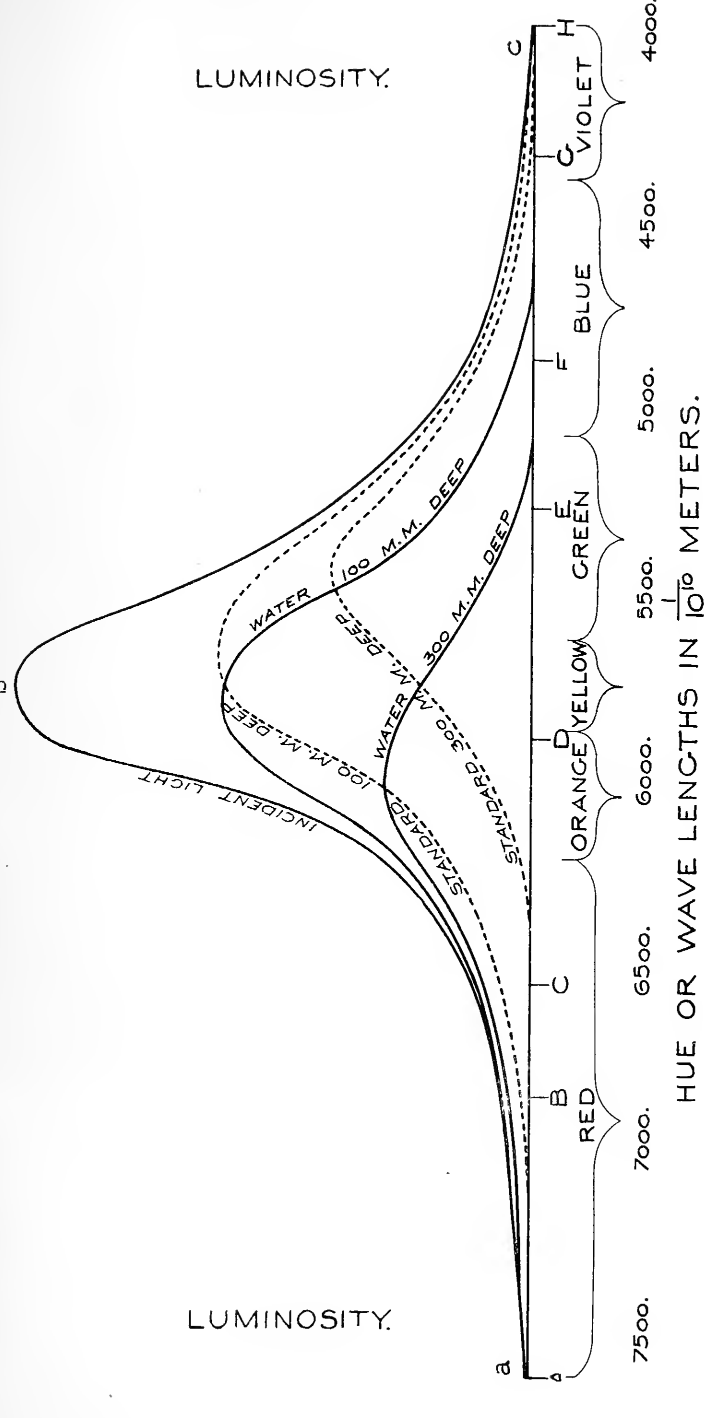
Natural Water Scale	.10	.20	.30	.40	.50	.60	.70	.80	.90	1.00
Equivalent on Platinum Scale	.18	.26	.33	.39	.46	.52	.58	.63	.70	.81

For standards darker than 1.00 no satisfactory comparisons have yet been made. For reading colors darker than 1.00 it has been found best either to read in shorter depths or else dilute with distilled water in order to bring the color within the range of the 1.00 standard. The latter method has been adopted at the filter station. The reason for this is that it is often difficult to compare the dark waters with the standard, owing to a difference of hue. It has been found that the amount of light which passes through a number of equal layers of an absorbing solution diminishes in geometrical progression as the number of layers increase in arithmetical progression. Thus if I denotes the intensity of the incident light, Ia will be the intensity after transmission through unit thickness, where a is a proper fraction, and depends upon the nature of the substance and the refrangibility of the light employed. For a given wave length, a will be different for different substances; and for a given substance, a will vary with the wave length. The quantity a is termed the coefficient of transmission.[1]

It is because of the fact that the coefficient of transmission for the different rays varies with different solutions that we sometimes find a water matches the standard very closely in hue in a short depth, but appears of quite a different hue in a greater depth. This can be represented by a diagram as follows: Let the ordinates of the curve *a b c* in diagram Plate 3 represent the intensities of the incident rays of light from the red to the violet, which fall upon a water and the standard with which it is being compared. Then assuming

[1] Thos. Preston — "The Modern Theory of Light."

PLATE 3.


LUMINOSITY.
LUMINOSITY.
a
b
c
INCIDENT LIGHT
WATER 100 M.M. DEEP
WATER 300 M.M. DEEP
STANDARD 100 M.M. DEEP
STANDARD 300 M.M. DEEP
A
B
C
D
E
F
G
H
RED
ORANGE
YELLOW
GREEN
BLUE
VIOLET
7500.
7000.
6500.
6000.
5500.
5000.
4500.
4000.
HUE OR WAVE LENGTHS IN $\frac{1}{10^{10}}$ METERS.

the following coefficients of transmission for a depth of 100 millimeters:

	Standard.	Water.
Red	.1	.9
Orange	.5	.8
Yellow	.6	.6
Green	.9	.5
Blue	.9	.1
Violet	.9	.1

the intensities of the different rays after traversing 100 millimeters would equal their original intensity multiplied by their respective coefficients.

The intensities after traversing a depth of 300 millimeters would equal the original intensity multiplied by the third power of their respective coefficients, giving the following:

	Standard.	Water.
Red	.001	.729
Orange	.125	.512
Yellow	.216	.216
Green	.729	.125
Blue	.729	.001
Violet	.729	.001

Plotting these values gives the curves in the diagram. The upper curve shows the intensity of the different colors in the incident light, and the four other curves show the intensities after having passed through 100 and 300 millimeters of the standard and water respectively. Comparing the intensities after passing 100 millimeters of the water with those of the standard for the same depth, it is noticed that they do not differ much in hue or luminosity. Comparing the intensities after passing 300 millimeters of standard and water it is noticed that the hue of the water has approached the red, while that of the standard has approached the blue. These hues would, therefore, be quite different, and could not be accurately compared. The relative luminosity has also changed, the standard having become somewhat brighter than the water.

The platinum standard which has been found to match the Boston water best contains twenty-five parts of cobalt to fifty parts of platinum.

The water in summer is usually redder than the standard, while in winter it is greener.

Color readings made by different observers have been found to agree to within .02. Occasionally differences of .05 or more are found. These differences are usually found

in cases where the water, from turbidity or other causes, differs from the standard in hue. This renders the comparison difficult, and the result depends largely upon the judgment of the observer.

The accuracy at present attained in color readings is probably quite sufficient for practical purposes.

From the reduction of color of a water by filtration at the filter station, it is possible to judge of the probable reduction of the organic matter.

The principal difficulty in the way of greater accuracy in color readings is the difference in hue between the prepared standard and the water. Maxwell, Young, and Holmholtz claim that all color perceptions are due to the simultaneous excitation of three sets of nerve ends in the eye, and that all colors can be produced by a combination of three colors, red, green and blue, in the proper proportion.

It is possible that a colorimeter might be constructed on this principle by employing standard red, green, and blue solutions, so arranged that they could be combined in all proportions. A solution would also probably have to be employed to give the effect of turbidity to the standard.

With a colorimeter of this kind much more time would be required to make the comparisons.

Prof. Ogden N. Rood[1] has employed these three constants to define completely a color:

1st. Purity, or freedom from white light.

2d. Luminosity or brightness.

3d. Hue or wave length.

To measure the color produced by the absorption of a water it could be arranged so that the measurement of the first constant would not be necessary. The light after passing through the water would consist of several components. It would be necessary to separate these by means of a prism or grating, and compare the spectrum thus obtained with the spectrum of the original light. The measurement of the hues could then be accurately made, and the luminosity would remain as a photometric problem. It appears, therefore, that in order to obtain much greater accuracy in color readings than is at present possible, more time and expensive apparatus must be employed.

With the colorimeter herein described and the platinum standards, it is, however, possible to read the colors of waters quickly, and generally with a probable error of but .01 or .02, which is sufficiently near for all practical purposes.

[1] Text-Book of Color, by Ogden N. Rood, 1892.

It would tend to uniformity of results and facilitate comparisons if all color readings were made on the uniform depth herein described, all waters darker than 1.00 being diluted as set forth on page 86.

QUALITY OF THE WATER.

The quality of the water has on the whole been very good throughout the year.

The following tables give, first, the average condition of the water as delivered at a tap in Boston during 1893; and, secondly, means of monthly analyses in 1893 of different parts of the supply. They afford a ready means of comparison with the condition of the water as given in the last annual report.

The succeeding tables contain the average results of biological examinations made during the past year, together with temperature observations and rainfall records.

Very truly yours,

DESMOND FITZGERALD,

Res't Eng'r Add'l Supply and Supt. West'n Div.

TABLE I. — Tap Water, Boston, 1893. Thomas M. Drown, M.D.

PARTS IN 100,000.

Locality.	Color.	Residue on Evaporation.			Chlorine.	Nitrogen.					Oxygen Consumed.	Hardness.	Remarks.
		Total.	Loss on Ignition.	Fixed.		Albuminoid Ammonia.		Free Ammonia.	As Nitrites.	As Nitrates.			
						Unfiltered.	Filtered.						
Service-pipe, Mass. Inst. of Technology .	0.61	4.54	1.84	2.70	.38	.0173	.0147	.0010	.0001	.0143	.60	1.8	Means of monthly analyses.

TABLE II.

Means of Monthly Analyses, January 1 to December 31, 1893, by Thomas M. Drown, M.D.

PARTS IN 100,000.

LOCALITY.	Color.	Residue on Evaporation.			Chlorine.	Nitrogen.					Oxygen Consumed.	Hardness.	REMARKS.
						Albuminoid Ammonia.							
		Total.	Loss on Ignition.	Fixed.		Unfiltered.	Filtered.	Free Ammonia.	As Nitrites.	As Nitrates.			
Sudbury River, upper end Res. No. 2	0.99	4.57	2.03	2.54	.34	.0232	.0196	.0019	.0001	.0068	.82	1.4	Samples collected 1 foot beneath surface.
Reservoir No. 2, near gate-house	0.98	4.28	1.86	2.42	.30	.0219	.0190	.0009	.0001	.0054	.81	1.2	Samples collected 8 feet beneath surface.
Stony Brook, upper end Res. No. 3	0.95	6.03	2.27	3.76	.50	.0273	.0237	.0027	.0002	.0127	.82	2.0	Samples collected 1 foot beneath surface.
Reservoir No. 3, near gate-house	0.90	4.97	2.10	2.87	.37	.0259	.0207	.0020	.0001	.0100	.77	1.7	Samples collected 8 feet beneath surface.
Cold Spring Brook, at head of Res. No. 4,	1.23	4.52	2.16	2.36	.26	.0248	.0212	.0013	.0001	.0031	.98	1.3	Samples collected 1 foot beneath surface.
Reservoir No. 4, near gate-house	0.77	3.54	1.63	1.91	.23	.0206	.0173	.0023	.0001	.0048	.68	1.0	Samples collected 1 foot beneath surface.
Lake Cochituate, gate-house	0.21	4.64	1.57	3.07	.46	.0168	.0138	.0015	.0002	.0098	.39	2.0	
Service-pipe, Mass. Inst. Tech., Boston	0.61	4.54	1.84	2.70	.38	.0173	.0147	.0010	.0001	.0143	.60	1.8	

Lake Cochituate, 1893.

Month.	Organisms.				Amorphous.				Remarks.
	Sur.	Mid.	Bot.	Mean.	Sur.	Mid.	Bot.	Mean.	
January	284	299	394	322	154	164	398	239	Diatomaceæ. (Asterionella. Stephanodiscus.)
February	38	91	124	84	126	257	446	276	Diatomaceæ.
March	9	24	117	50	118	148	402	223	Diatomaceæ.
April	207	212	254	224	206	257	286	250	Diatomaceæ. (Melosira. Asterionella.)
May	735	679	846	753	257	374	713	448	Diatomaceæ. (Melosira. Asterionella. Stephanodiscus.)
June	553	203	210	322	187	171	434	264	Diatomaceæ. (Tabellaria. Stephanodiscus. Asterionella. Melosira.) Chlorophyceæ. Cyanophyceæ.
July	244	200	309	251	171	236	1,674	694	Diatomaceæ. Chlorophyceæ. Cyanophyceæ (Microcystis). Fungi (Crenothrix).
August	353	363	170	295	200	238	2,384	941	Diatomaceæ. Chlorophyceæ. Cyanophyceæ (Microcystis). Fungi (Crenothrix).
September	486	438	150	358	203	185	1,221	536	Diatomaceæ. Chlorophyceæ. Cyanophyceæ (Microcystis).
October	675	540	255	490	660	567	2,959	1,395	Diatomaceæ. Chlorophyceæ. Cyanophyceæ (Microcystis. Clathrocystis).
November	635	530	424	530	695	696	1,179	857	Diatomaceæ (Tabellaria. Melosira). Chlorophyceæ. Cyanophyceæ (Microcystis). Fungi (Crenothrix).
December	453	454	544	484	456	434	492	461	Diatomaceæ (Tabellaria. Melosira). Cyanophyceæ.
Mean	389	336	316	347	286	311	1,049	549	

Zoospores, Desmidieæ, Infusoria, Rotifera, Crustacea present throughout the year. Results are expressed in "number of standard units per c.c."

Basin 2, 1893.

MONTH.	ORGANISMS.					AMORPHOUS.					REMARKS.
	Sur.	Mid.	Bot.	Mean.	Influent.	Sur.	Mid.	Bot.	Mean.	Influent.	
January	16	9	43	23	10	292	237	159	229	164	Diatomaceæ.
February	6	5	5	5	7	175	162	232	190	134	"
March	3	2	2	2	11	88	72	105	88	123	"
April	14	13	21	16	18	94	107	99	100	123	"
May	37	60	48	48	61	200	226	282	236	156	" { Synedra. Tabellaria.
June	54	83	52	63	85	255	322	586	388	170	{ " Chlorophyceæ.
July	191	154	206	184	43	466	532	619	539	199	{ Diatomaceæ (Cyclotella). Chlorophyceæ. Cyanophyceæ.
August	355	261	234	283	105	558	573	640	590	533	{ Diatomaceæ (Cyclotella). Chlorophyceæ. Cyanophyceæ.
September	246	181	276	234	168	595	495	776	622	207	{ Diatomaceæ (Cyclotella). Chlorophyceæ. Cyanophyceæ.
October	355	308	208	290	90	1,530	1,394	1,451	1,458	466	{ Diatomaceæ. { Synedra. Cyclotella. Chlorophyceæ.
November	102	94	79	92	41	1,227	1,355	1,599	1,394	645	Diatomaceæ.
December	9	5	7	7	8	494	519	541	518	398	"
Mean	116	98	98	103	53	498	499	591	529	277	

Infusoria and Rotifera often present.

Basin 3, 1893.

Month.	Organisms.					Amorphous.					Remarks.
	Sur.	Mid.	Bot.	Mean.	Influent.	Sur.	Mid.	Bot.	Mean.	Influent.	
January	127	147	117	131	13	126	171	244	180	217	Diatomaceæ (Tabellaria).
February	41	9	9	19	4	741	781	534	685	99	
March	25	10	18	18	13	144	161	157	154	86	
April	46	40	48	45	22	219	177	232	209	82	Diatomaceæ. Synedra. Tabellaria.
May	266	245	268	260	75	283	325	603	404	177	Diatomaceæ. Synedra. Tabellaria. Asterionella.
June	191	104	92	129	51	175	266	389	277	176	Diatomaceæ. Cyanophyceæ.
July	653	516	595	588	66	370	485	1,152	669	162	Chlorophyceæ (Protococcus). Cyanophyceæ.
August	432	329	302	354	74	402	459	1,504	788	285	Chlorophyceæ. Cyanophyceæ (Coelosphærium).
September	1,110	955	827	964	141	433	408	529	457	161	Chlorophyceæ. Cyanophyceæ (Coelosphærium).
October	1,223	983	1,091	1,099	94	2,323	2,471	3,215	2,669	221	Chlorophyceæ. Diatomaceæ. Tabellaria. Asterionella. Cyanophyceæ.
November	363	233	303	300	169	1,281	1,227	1,610	1,373	984	Diatomacoæ. Chlorophyceæ. Cyanophyceæ (Infusoria).
December	95	59	64	73	16	422	326	368	372	198	Infusoria.
Mean	381	303	311	332	62	577	605	878	687	237	

Zoospores, Desmidieæ, Infusoria, and Rotifera often present.

Basin 4, 1893.

Month.	Organisms.					Amorphous.					Remarks.
	Sur.	Mid.	Bot.	Mean.	Influent.	Sur.	Mid.	Bot.	Mean.	Influent.	
January	41	82	53	59	8	115	223	248	195	56	Diatomaceæ.
February	4	5	9	6	17	194	152	166	171	166	
March	1	2	5	3	4	67	96	113	92	69	
April	7	5	7	6	8	71	93	85	83	44	
May	43	30	15	29	24	146	173	145	155	85	Diatomaceæ. Chlorophyceæ.
June	183	78	29	97	31	162	154	156	157	144	Diatomaceæ. Chlorophyceæ.
July	91	45	22	53	25	121	111	159	130	101	Diatomaceæ.
August	230	58	41	110	85	233	165	141	180	150	Diatomaceæ. Chlorophyceæ.
September	164	150	128	147	14	255	246	308	270	86	Chlorophyceæ.
October	372	302	241	305	53	819	592	623	679	268	Diatomaceæ. Chlorophyceæ.
November	200	238	240	226	24	1,913	2,065	2,340	2,106	382	Diatomaceæ. Zoospores.
December	10	....	....	10	10	550	....	....	550	425	
Mean	112	84	66	87	25	387	385	420	397	165	

TABLE III.

Month.	Chestnut Hill Reservoir. Organisms. Sudbury.	Chestnut Hill Reservoir. Organisms. Cochituate.	Chestnut Hill Reservoir. Organisms. Effluent.	Chestnut Hill Reservoir. Amorphous. Sudbury.	Chestnut Hill Reservoir. Amorphous. Cochituate.	Chestnut Hill Reservoir. Amorphous. Effluent.	Brookline Gate-House. Organisms.	Brookline Gate-House. Amorphous.	Taps in City. Organisms. Park Sq.	Taps in City. Organisms. Mattapan.	Taps in City. Amorphous. Park Sq.	Taps in City. Amorphous. Mattapan.
January	148	196	109	177	134	162	133	136	66	57	98	122
February	9	36	13	176	158	177	15	131	14	9	84	44
March	10	19	10	98	111	107	6	107	5	7	88	46
April	20	173	47	121	156	138	64	128	46	46	116	72
May	112	626	321	261	303	237	219	184	212	103	396	88
June	92	550	463	438	210	232	318	236	308	66	324	90
July	357	227	592	408	179	266	464	287	336	96	372	125
August	183	221	307	395	175	265	223	240	199	49	318	123
September	259	445	455	555	195	269	305	300	347	205	299	157
October	870	528	714	2,373	492	536	586	561	679	330	441	187
November	165	584	520	2,120	594	647	445	731	311	84	447	225
December	16	448	218	677	389	326	209	643	155	48	185	101
Mean	187	338	314	650	256	280	249	307	223	92	264	115

Temperatures (Fahrenheit), 1893.

Month.	Lake Cochituate.			Basin 2.			Basin 3.			Basin 4.		
	Sur.	Mid.	Bot.	Sur.	Mid.	Bot.	Sur.	Mid.	Bot.	Sur.	Mid.	Bot.
January	34.8	36.6	38.3	33.5	34.9	36.0	33.7	35.4	37.5	34.7	37.4	38.7
February	35.0	37.3	38.4	33.0	34.2	35.5	33.2	35.1	37.6	34.3	38.0	39.3
March	35.5	37.4	38.6	33.7	34.3	35.5	33.5	35.0	36.5	33.3	36.0	39.0
April	42.4	41.8	41.6	44.0	44.0	44.0	43.0	43.1	43.2	41.6	41.8	42.0
May	56.7	46.8	44.9	58.7	57.6	56.4	57.1	55.8	54.7	57.1	51.9	48.8
June	69.7	47.9	45.1	71.1	69.3	67.0	71.4	68.3	66.1	70.5	59.8	49.9
July	73.9	48.1	45.0	75.9	74.0	73.0	74.7	72.4	69.3	75.1	61.4	50.8
August	72.5	50.3	44.9	73.6	72.8	71.9	72.7	72.0	70.1	73.0	61.1	51.3
September	65.9	49.5	44.9	65.2	64.9	64.5	65.1	64.8	64.6	64.4	61.1	56.4
October	56.8	52.3	45.1	55.7	55.5	55.4	55.0	54.8	54.7	54.7	54.7	54.8
November	46.5	46.3	44.5	39.2	39.1	39.0	38.4	38.5	38.6	39.8	43.5	43.8
December	36.4	37.3	39.6	33.3	33.8	34.5	33.2	34.4	36.1	32.8	.....	.....
Mean	52.2	44.3	42.6	51.4	51.2	51.1	50.9	50.8	50.8	50.9	48.3	45.6

The above figures are based on weekly observations.

Table IV. — Temperatures (Fahrenheit), 1893.

Months.	Chestnut Hill Reservoir Gate-Houses.			Chestnut Hill Reservoir.			Brookline Gate-House.	Taps.	
	Sudbury.	Cochituate.	Effluent.	Surface.	Middle.	Bottom.		Park Sq.	Mattapan.
January	37.1	36.5	35.7	34.4	35.6	35.9	36.7	36.7	38.5
February	34.8	36.6	34.9	33.9	35.2	35.4	36.1	36.1	35.9
March	34.6	37.1	35.0	32.9	34.7	35.0	35.8	35.8	36.0
April	43.7	41.5	43.0	42.8	42.8	42.9	42.8	41.7	39.6
May	55.0	53.4	54.8	57.5	54.7	51.4	54.2	53.7	47.9
June	66.1	66.0	67.0	71.9	66.3	56.6	66.7	65.7	57.2
July	72.4	73.1	72.3	75.1	72.0	60.6	72.7	71.7	62.7
August	70.8	71.9	73.3	72.5	70.6	65.3	72.1	71.1	64.5
September	65.8	66.4	66.6	66.6	66.7	66.0	66.3	65.5	62.4
October	57.9	58.3	58.1	59.1	58.4	58.1	58.2	57.5	57.3
November	42.1	47.9	45.1	45.8	45.5	45.6	46.3	47.0	50.2
December	36.4	39.0	37.0	38.0	39.5	39.0	37.7	42.1	42.8
Mean	51.4	52.3	51.9	52.5	51.8	49.3	52.1	52.0	49.6

The above figures are based on weekly observations.

Table V. — Colors, 1893. (Nessler Scale.)

Month.	Lake Cochituate.					Basin 2.					Basin 3.					Basin 4.				
	Sur.	Mid.	Bot.	Mean.	Influent.[1]	Sur.	Mid.	Bot.	Mean.	Influent.	Sur.	Mid.	Bot.	Mean.	Influent.	Sur.	Mid.	Bot.	Mean.	Influent.
January	.20	.24	.40	.28	.60	1.18	1.26	1.28	1.24	1.18	.94	.98	1.12	1.01	.94	.97	1.01	1.06	1.01	1.20
February	.25	.29	.52	.35	.86	1.04	1.03	1.01	1.03	1.16	.91	.91	.91	.91	1.09	.96	.96	.98	.97	1.06
March	.34	.26	.62	.41	.70	.93	.92	.87	.91	.91	.84	.81	.82	.82	.88	.94	.92	.92	.93	1.06
April	.37	.41	.41	.40	1.26	.90	.90	.90	.90	.97	.82	.82	.81	.82	1.08	.94	.94	.94	.94	1.11
May	.32	.33	.37	.34	1.19	1.14	1.14	1.18	1.15	1.25	1.10	1.09	1.13	1.11	1.44	1.00	.96	.95	.97	1.59
June	.29	.25	.86	.47	1.06	1.26	1.26	1.27	1.26	1.31	1.18	1.23	1.31	1.24	1.48	1.03	1.00	.97	1.00	1.62
July	.18	.17	1.00	.45	.53	1.00	1.02	1.01	1.01	.91	.97	.99	1.05	1.00	.93	.75	.75	.74	.75	.84
August	.17	.18	1.32	.56	.83	.86	.88	.86	.87	.78	.85	.88	1.10	.94	.56	.69	.70	.66	.68	1.12
September	.14	.20	1.28	.54	.34	.70	.72	.75	.72	.66	.82	.83	.85	.83	.40	.65	.68	.72	.68	.93
October	.15	.23	1.63	.67	.90	.59	.61	.61	.60	.65	.83	.88	.89	.87	.48	.59	.58	.59	.59	.90
November	.20	.21	.60	.34	.50	1.14	1.14	1.15	1.14	1.40	.87	.87	.85	.86	.75	1.31	1.22	1.32	1.28	1.66
December	.19	.21	.25	.22	.77	1.17	1.19	1.18	1.18	1.16	.84	.84	.81	.83	.86	1.37	...	...	1.37	1.24
Mean	.23	.25	.77	.42	.80	.99	1.01	1.01	1.00	1.03	.91	.93	.97	.94	.91	.93	.92	.94	.93	1.19

[1] Estimate based on colors taken in Beaver dam, Course, Pegan (filter-beds), and Snake brooks, and disregarding spring-water.

Table V. — Colors, 1893. — *Concluded.*

Month.	Chestnut Hill Reservoir Gate-Houses.			Chestnut Hill Reservoir.			Brookline Gate-House.	Taps.	
	Sudbury.	Cochituate.	Effluent.	Surface.	Middle.	Bottom.		Park Sq.	Mattapan.
January	1.15	.18	1.05	1.03	1.03	1.04	.94	1.04	.97
February	.91	.23	.83	.80	.81	.81	.74	.82	.75
March	.85	.38	.75	.78	.78	.78	.64	.69	.67
April	.85	.25	.60	.63	.63	.63	.56	.59	.53
May	1.03	.27	.66	.65	.67	.65	.64	.70	.62
June	1.24	.28	.86	.87	.87	.66	.85	.92	.65
July	.92	.17	.61	.61	.64	.51	.61	.62	.53
August	.82	.14	.53	.51	.51	.53	.45	.51	.42
September	.63	.12	.40	.40	.41	.42	.39	.41	.32
October	.69	.14	.37	.39	.40	.41	.38	.40	.31
November	.98	.22	.44	.46	.44	.44	.44	.47	.37
December	.89	.16	.61	.53	.51	.51	.61	.64	55
Mean	.91	.22	.65	.64	.64	.62	.61	.65	.56

Bacteria, 1893.

Month.	Chestnut Hill Reservoir Gate-Houses.			Chestnut Hill Reservoir.			Brookline Gate-House.	Taps.	
	Sudbury.	Cochituate.	Effluent.	Surface.	Middle.	Bottom.		Park Square.	Mattapan.
January	446	76	273	338	279	383	199	257	58
February	1,440	446	758	763	738	772	694	690	178
March	912	1,189	622	87	175	328	746	110	52
April	85	134	178	59	242	262	70	54	73
May	179	119	253	48	323	359	81	63	155
June	279	281	573	52	326	484	49	64	171
July	287	434	205	150	382	352	65	97	229
August	339	123	523	142	360	413	71	103	76
September	108	195	447	36	533	422	89	75	51
October	43	67	86	26	101	99	44	68	84
November	252	40	63	18	192	306	30	59	53
December	109	55	60	18	205	285	58	79	84
Mean	373	263	280	145	321	372	183	143	97

Maintenance of Western Division for 1893-4.

DRAFTS.	Western Division.	Basins.	Sudbury Aqueduct.	Cochituate Aqueduct.	Lake Cochitua'e.	Pegan Filters.	Chestnut Hill Reservoir.	Chestnut Hill Driveway.	Brookline Reservoir.	Fisher Hill Reservoir.	Biological Dept.	Inspection Dept.	Filtration.	Totals.
February 1, 1893 . .	$323 46	$274 24	$102 05	$218 48	$61 05	. . . . .	$166 99	$174 99	$17 85	$11 90	$114 01	$80 80	$500 98	$2,046 80
March 1, " . .	800 15	647 83	426 91	295 21	215 32	$291 13	1,144 68	994 84	72 01	229 75	553 56	399 84	792 77	6,864 00
April 1, " . .	725 98	607 54	354 55	260 75	244 09	217 38	979 24	1,012 82	131 65	88 00	370 13	337 01	687 00	6,016 14
May 1, " . .	1,121 34	1,165 05	468 04	177 03	293 16	378 50	1,469 77	826 21	113 25	185 50	521 59	451 58	642 64	7,813 66
June 1, " . .	1,070 93	421 65	537 70	97 68	232 94	1,943 80	966 28	962 68	66 25	101 97	252 75	370 16	496 91	7,521 70
July 1, " . .	1,153 73	715 45	604 37	35 50	156 18	4,929 27	1,287 51	915 54	101 96	99 36	248 89	412 74	489 16	11,149 66
August 1, " . .	1,133 64	592 81	625 23	117 50	248 16	3,928 19	1,406 82	1,253 63	201 00	175 75	295 60	418 56	611 76	11,008 65
September 1, " . .	1,107 36	393 45	666 45	133 25	266 92	1,517 26	913 85	1,102 14	35 00	66 00	283 69	375 91	536 54	7,397 82
October 1, " . .	1,154 73	505 03	772 53	148 75	220 88	1,318 12	1,241 84	973 72	78 75	170 00	268 06	359 51	580 58	7,792 50
November 1, " . .	1,072 89	1,640 41	491 53	196 20	278 55	208 43	1,885 25	793 29	153 00	216 00	338 16	425 41	699 48	8,398 60
December 1, " . .	1,087 56	1,125 57	431 54	272 02	210 62	368 67	1,637 72	636 52	132 80	112 50	352 13	400 10	592 51	7,360 26
January 1 & 31, 1894,	1,934 62	1,158 00	889 84	195 75	2,918 88	868 00	2,892 10	1,696 17	87 75	147 50	701 62	723 02	903 63	15,116 88
Totals	$12,686 39	$9,247 03	$6,370 74	$2,148 12	$5,346 75	$15,968 75	$15,992 05	$11,342 55	$1,191 27	$1,604 23	$4,300 19	$4,754 64	$7,533 96	$98,486 67

Table of Rainfall at Chestnut Hill Reservoir for Year ending December 31, 1893.

DATE.	Inches.	Snow or Rain.	Duration.
Jan. 1	1.04	Snow and Rain.	9.45 a.m. to
" 2			3.00 a.m.
" 5	0.63	Snow.	5.00 a.m. to
" 6			5.15 p.m.
" 9	0.54	"	1.15 p.m. to 10.00 p.m.
" 15	0.10	"	5.00 a.m. to 6.30 p.m.
" 29	0.43	Rain.	2.00 a.m. to 6.30 p.m.
Total.	2.74		
Feb. 3	0.50	Rain.	8.10 a.m. to 3.00 p.m.
" 6	0.54	Snow and Rain.	9.30 a.m. to
" 7			5.00 a.m.
" 9	1.08	Snow and Rain.	10.30 p.m. to
" 10			3.00 p.m.
" 13	1.44	Snow and Rain.	8.30 a.m. to 9.30 p.m.
" 17	1.55	Snow.	8.30 p.m. to
" 18			8.00 p.m.
" 22	2.25	Snow and Rain.	12.30 a.m. to 10.30 p.m.
" 24	0.23	Snow.	2.30 a.m. to 9.30 a.m.
" 25	0.28	"	4.45 p.m. to 11.15 p.m.
" 28	0.22	"	7.00 p.m. to midnight.
Total.	8.09		
Mar. 1	0.22	Snow.	midnight Feb. 28 to 7.15 a.m.
" 4	0.20	"	4.00 a.m. to 3.30 p.m.
" 9	1.55	Rain.	3.00 a.m. to
" 10			7.45 a.m.
" 11	0.30	"	9.30 p.m. to
" 12			4.00 p.m.
" 14	1.00	Rain and Snow.	11.00 p.m. to
" 15			7.50 a.m.
" 22	0.10	Snow.	5.00 p.m. to
" 23			3.00 p.m.
Total.	3.37		

DATE.	Inches.	Snow or Rain.	Duration.
Apr. 4	0.07	Rain.	8.00 p.m. to 9.00 p.m.
" 6	0.23	Snow.	1.45 a.m. to 9.30 a.m.
" 7	0.53	Snow and Rain.	1.15 p.m. to
" 8			4.30 a.m.
" 8	0.18	Rain.	12.55 p.m. to 2.45 p.m.
" 8	0.10	Rain.	4.00 p.m. to 5.00 p.m.
" 14	0.73	"	4.40 p.m. to
" 15			6.30 p.m.
" 20	1.17	"	3.15 p.m. to
" 21			12.30 p.m.
" 25	0.14	"	7.45 a.m. to 4.00 p.m.
" 27	0.17	"	7.15 a.m. to 5.15 p.m.
Total.	3.32		
May 1	3.36	Rain.	12.45 a.m.
" 2			to
" 3			
" 4			12.15 p.m.
" 13	0.50	"	7.50 a.m. to 11.30 p.m.
" 16	1.40	"	4.00 p.m. to
" 17			8.00 a.m.
" 26	0.03	"	6.00 p.m. to 8.30 p.m.
" 27	0.48	"	7.50 p.m. to 8.30 p.m.
Total.	5.77		
June 13	0.55	Rain.	5.00 p.m. to
" 14			11.30 a.m.
" 17	0.24	"	7.00 a.m. to 7.00 p.m.
" 22	1.50	"	7.30 a.m.
" 23			to
" 24			6.00 a.m.
" 24	0.04	"	9.00 p.m. to 9.30 p.m.
Total.	2.33		

Table of Rainfall at Chestnut Hill Reservoir. — *Concluded.*

Date.	Inches.	Snow or Rain.	Duration.
July 5	0.24	Rain.	9.45 p.m. to 11.30 p.m.
" 8	0.07	"	8.00 p.m. to 8.30 p.m.
" 12	0.10	"	4.30 p.m. to 8.30 p.m.
" 18	0.73	"	7.45 p.m. to 8.30 p.m.
" 22	0.67	"	6.55 p.m. to 11.15 p.m.
" 23	0.16	"	2.15 p.m. to 2.55 p.m.
" 25	0.10	"	6.30 p.m. to 8.00 p.m.
" 26	0.03	"	8.00 p.m. to 8.30 p.m.
Total.	2.10		
Aug. 4	1.99	Rain.	8.00 p.m. to
" 5			4.30 p.m.
" 6	1.48	"	5.40 p.m. to
" 7			2.00 a.m.
" 7	0.03	"	11.20 a.m. to 11.40 a.m.
" 7	0.33	"	4.50 p.m. to 6.10 p.m.
" 17	0.09	"	1.00 p.m. to 6.30 p.m.
" 18	0.04	"	12.30 p.m. to 3.00 p.m.
" 20	1.84	"	8.15 p.m. to
" 21			2.30 p.m.
" 24	0.35	"	6.30 a.m. to 1.00 p.m.
" 29	0.38	"	6.40 a.m. to 2.30 p.m.
Total.	6.53		
Sept. 1	0.36	Rain.	8.00 p.m. to
" 2			5.30 a.m.
" 7	0.46	"	7.50 p.m. to 11.00 p.m.
" 15	0.02	"	6.30 a.m. to 7.00 a.m.
" 16	0.56	"	1.00 p.m. to 4.00 p.m.
" 19	0.23	"	12.05 p.m. to 3.15 p.m.
" 23	0.05	"	6.30 p.m. to 7.15 p.m.
" 25	0.12	"	9.30 a.m. to 8.30 p.m.
" 29	0.05	"	4.15 p.m. to 8.00 p.m.
Total.	1.85		

Date.	Inches.	Snow or Rain.	Duration.
Oct. 13	1.39	Rain.	11.00 p.m. to
" 14			10.45 a.m.
" 23	2.02	"	7.00 a.m. to
" 24			10.00 a.m.
" 27	0.29	"	10.00 p.m. to
" 28			10.00 a.m.
Total.	3.70		
Nov. 4	0.71	Rain.	11.30 a.m. to
" 5			2.00 a.m.
" 15	0.19	"	5.30 a.m. to 3.00 p.m.
" 20	0.02	Snow.	7.00 a.m. to 9.30 a.m.
" 22	0.65	Rain.	12.30 a.m. to 11.00 a.m.
" 28	0.43	"	2.20 a.m. to 11.30 a.m.
Total.	2.00		
Dec. 1	0.39	Rain.	7.30 a.m. to 8.00 p.m.
" 3	1.56	Snow and Rain.	3.00 a.m. to
" 4			9.00 a.m.
" 5	0.67	Snow.	11.15 a.m. to 11.45 p.m.
" 9	0.35	Snow and Rain.	2.40 p.m. to
" 10			7.15 a.m.
" 14	1.54	Snow and Rain.	7.45 p.m. to
" 15			
" 16			
" 17			2.00 a.m.
" 19	0.03	Snow.	5.00 a.m. to 8.30 a.m.
" 23	0.07	Rain.	3.30 a.m. to 6.00 a.m.
" 23	0.01	"	12.30 p.m. to 2.00 p.m.
" 29	0.05	"	11.45 a.m. to 4.30 p.m.
" 30	0.24	Snow.	1.15 p.m. to
" 31			3.00 p.m.
Total.	4.91		

Total Rainfall for year, 46.71 inches.

REPORT OF THE SUPERINTENDENT OF THE MYSTIC DIVISION.

OFFICE OF SUPERINTENDENT,
CORNER OF MEDFORD AND TUFTS STREETS,
BOSTON, February 1, 1894.

COL. THOMAS F. DOHERTY,
Chairman Boston Water Board:

SIR: The report of the Mystic Division of the Boston Water-Works from February 1, 1893, to February 1, 1894, is herewith submitted.

MYSTIC LAKE.

The water in the lake was lower last fall than it has been since 1880, and it was necessary to pump into the conduit. Water was wasting over the dam until June 7, then gradually lowered, and as it drew near the pumping point, the temporary engines were overhauled and repacked.

The centrifugal pumps were lowered into place, the strainers enlarged; a new and larger flume built, 20 feet long by 9½ feet wide by 3½ feet deep, from the discharge pipes to the conduit; the coal-bunkers were rearranged, and another feed-pump set up. It required a few days' testing to get the engines and pumps into working order.

On October 19 the surface of the lake was at 8.50 below high water, or 2.67 above the conduit invert. The pumps were started and were worked constantly until November 4, when the water had risen sufficiently to gravitate to the pumping-station. On October 23 the lake was at its lowest, 8.90 feet below high water, or 2.27 feet above the conduit invert. This was within 1.27 feet of the lowest point ever reached, which was on October 25, 1880. After November 4 the lake regained very slowly, but about the middle of December the water began to rise rapidly, and continued until January 19, when water again overflowed the dam. In the upper portion of Mystic lake, the lowness of the water already referred to exposed about 20 acres of a black vegetable mould, favorable to the growth of algæ.

This section, locally known as "Bacon's pond," had been a meadow previous to the construction of the dam, but is now overflowed the greater part of the year. To remove the

objectionable matter a large additional force of men and teams were employed. A great many tree stumps and about 14,000 cubic yards of soil were removed, and the refuse was disposed of by grading the land bordering the east side of the lake, and by filling the nooks and shallow parts along the banks. Two large inlets, especially, were filled in and the bank slopes surfaced with gravel. The work was continued about three weeks, but it was suspended because of the rise of the water.

RESERVOIR.

The customary care was taken of the banks, walks, and roads surrounding the reservoir, and a number of minor repairs attended to. Each year for several years past sections of the roads about the banks have been macadamized; the past year about 14,000 square feet of the work was done. The brickwork at the gate-house was repointed, and the old fence on the north side was taken down. I respectfully call the attention of the Board to the necessity of having the bottom of the reservoir puddled and concreted, and to the need of laying a 12-inch drain-pipe to the river for use when draining the reservoir.

CONDUIT.

The conduit was cleaned and inspected twice during the year and some repointing and repairing done. Part of the brick air-chamber was rebuilt and a new top put on. The conduit and the force-mains are in good condition.

The improvements proposed in my last report — the construction of a 36-inch gate and pipe on the blow-off, the renewing of the sills and grooves for the screens in the screen-chamber, and the raising of the roof of the chamber — I postponed, as more important and unexpected repairs necessitated the total expenditure of the appropriation.

PUMPING-STATION.

The daily average amount of water pumped during the past year was 11,163,000 gallons, and the daily average consumed was 11,161,600 gallons, an increase in consumption of 13.8 per cent. over the preceding year. In May, Engine No. 1 was disconnected, and found to be 7-16 of an inch out of line, and all the anchor bolts on the water cylinders badly decayed. After relining the engine and substituting a new set of anchor bolts, the steam cylinders were bedded in sulphur and the water cylinders in Portland cement.

Then the engine was bolted to the bed, the four cylinders were rebored and St. John's packing put on the pistons. The United States metallic packing on the piston-rods, in use for nineteen years, was overhauled, and after some remedying was replaced as good as new. Two new steel piston-rods were placed in the low-pressure cylinders, and the stuffing-boxes for the pump-rods on the water cylinders were rebushed with composition. The internal heads were remodelled with new rod-rings.

In the steam-chests, the valves were reset and the four balance-pistons replaced by new ones, and new steel pins put in the balance-valve links.

The throttle valves were repaired and the domes on the high-pressure steam-chests were each lengthened thirteen inches. Engine No. 1 is now running very smoothly, and will need no repairs of notice for several years to come. Engine No. 2 required but a few minor repairs the past year, and is in fair order. Engine No. 3 will be overhauled the coming spring and some needed repairs made. As the steel piston-rods in the independent air-pump for engines Nos. 1 and 2 are worn from corrosion, new bronze metal or composition ones will be substituted. Boilers Nos. 4, 5, and 6 were last inspected September 28, 1893, and boilers 1, 2, and 3 on January 31, 1894, and all pronounced in good condition. Boilers Nos. 1, 2, and 3 had received some slight repairs, and No. 4 had a new blow-off pipe put in. Owing to interference with the draught, the smoke consumers that were placed in the furnaces a few years ago were removed.

As the covering on boilers Nos. 1, 2, and 3 is badly worn, it will soon be renewed, and about 150 feet of 2-inch pipe will be covered. A 250-incandescent light dynamo and an Armington and Symmes' 18 horse-power engine were placed between engines Nos. 2 and 3, — the dynamo in the engine-room and the engine on a solid brick foundation in the basement. For the engine a 2-inch connection was made with both sets of boilers and a 2½-inch exhaust to the rear of the building.

About 150 feet of 16-inch drain-pipe with 3 six-inch connections were laid in front of the engine-house, and about 150 feet of the blow-off 12-inch drain relaid. The interior of the engineers' residences were painted, and when the gutters and the conductors are renewed, the exterior and the barn will be painted.

MYSTIC-VALLEY SEWER.

The quantity of sewage pumped during the past year was 123,569,531 gallons, to which 304,010 pounds of crude

sulphate of alumina were applied as a precipitant, thereby throwing down 3,291,701 gallons of sludge, which was pumped into the settling basins on the adjoining grounds. The solid sludge was removed for the most part by a neighboring farmer for agricultural purposes.

The amount of coal used was 231 tons. The engine was thoroughly overhauled last fall and is now running well. The tanks are apparently sound, but show signs of age, and the chemical vats, though rehooped and repaired, are nearing the end of their usefulness. Owing to the dryness of the season, the well that supplied the water for the boiler was running dry, so it was dug several feet deeper and plenty of water obtained.

Many improvements could be made at this station, but in view of its abandonment in the near future, I deem it inadvisable to expend any money upon it, except for essential purposes.

Sewage Treatment at Stoneham.

The chemical treatment of sewage at Tidd's Tannery, Stoneham, is progressing satisfactorily. After the tanks and the filter-beds were constructed and the sewage and sludge pumps set up, some delay was occasioned through insufficient power furnished by the tannery engine, but everything was finally adjusted and the chemical treatment commenced on March 28, 1893. The quantity of sewage pumped to February 1, 1894, was 5,226,184 gallons, an average of 22,000 gallons daily. The quantity of sludge pumped during the same time was 714,000 gallons, or 13 per cent. of the sewage. The amount of crude sulphate of alumina, applied as a precipitant, was 85,286 pounds, or at the rate of 1 part of precipitant to 511 parts of sewage.

Inspection of Water-Sources Department.

A summary of the inspection work for the past year as reported by Mr. John S. Concannon, Chief Inspector, is as follows: Total number of cases inspected, 678; of these there are, "Old Cases, 625;" "New Cases, 53." The present condition of all inspected cases is: "Present Safe," 447; "Seem Safe," 78; "Unsatisfactory," 46; "Suspected," 71; "Remedied," 36. Twenty-six legal notices were sent.

Intelligent and frequent inspections have produced good results. The authorities in the towns and city on the supply are willing and generous in every legal work tending towards the purity of the water.

This year Woburn will probably complete a large part of

its local sewer (system), consequently, as more than 50 per cent. of our pollution cases are in that city, considerable benefit will be derived.

FILTRATION EXPERIMENTS.

The two experimental filters at West Medford were in continuous operation for two years and a half, and weekly chemical and biological examinations were made of the Mystic water and of the effluents of these filters during this time. Prof. T. M. Drown, of the Massachusetts Institute of Technology, reports that the results of the experiments were in all respects satisfactory, the effluent water being clear and practically colorless and of a satisfactory degree of purity.

The average purification of the water during the last six weeks, while filtering at the rate of 2,500,000 gallons per acre daily, was as follows:

		Per cent.
1.	Removal of color	60.00
2.	" organic matter as determined by the albuminoid ammonia . . .	57.00
3.	" organic matter as determined by the "oxygen consumed" . . .	40.00
4.	" free ammonia	86.00
5.	" nitrites	100.00
6.	" microscopic organisms . . .	99.85
7.	" bacteria	99.76
8.	Increase of nitrates showing oxidation of organic matter	26.00

The sand in these filters was scraped from time to time as they became clogged, and for one foot in depth the sand was twice renewed during the thirty months.

The experiments show conclusively that the filtration of the Mystic supply through sand would furnish a water of attractive appearance and almost perfectly free from living organisms.

DISTRIBUTION PIPES.

The distribution pipes were extended by the addition of 290 feet of 2-inch pipe, 772 feet of 4-inch pipe, 11,770 feet of 6-inch pipe, 5,355 feet of 8-inch pipe, 3,354 feet of 10-inch pipe, 328 feet of 12-inch pipe, and 876 feet of 16-inch pipe. Twenty-eight thousand three hundred and twenty-nine feet of pipe have been relaid.

There are remaining in Charlestown 6,139 feet of cement-lined pipe, varying in size from 2 to 20 inches.

Hydrants and Gates.

Eighty-three new hydrants, 4 street Lowry hydrants, and 79 Post hydrants were established; 21 Post hydrants were abandoned, and 20 replaced; 146 additional gates were established: one 20-inch, eight 12-inch, two 16-inch, fourteen 10-inch, twenty-one 8-inch, seventy-eight 6-inch, eight 4-inch, and fourteen 3-inch gates. Eight 4-inch gates were abandoned. Twenty-six gate-boxes and eight hydrant-boxes were replaced by new ones.

Fountains and Stand-Pipes.

Two drinking-fountains were abandoned, and one new stand-pipe was erected for street-watering purposes.

Service-Pipes and Boxes.

Eight hundred and ten new services were laid, distributed as follows: Charlestown, 49; Chelsea, 105; Everett, 284; Somerville, 372; for which 23,100 feet of lead pipe and 139 feet of iron pipe were required. One hundred and thirty-seven services were repaired. Eleven service-pipes were removed and larger ones substituted. Twenty-four service-boxes were repaired.

Sixty-six stoppages by eels, twenty-two by rust, and one by moss were forced out.

Twenty-one leaking services were repaired and two frozen ones thawed out.

New Services.

Size	$\frac{1}{2}$-in.	$\frac{5}{8}$-in.	$\frac{3}{4}$-in.	1-in.	$1\frac{1}{4}$-in.	$1\frac{1}{2}$-in.	2-in.	4-in.	Total No.	Total ft.
Charlestown	1	20	14	3	3	2	4	2	49	1,332
Chelsea	39	62	4	...	...	...	...	...	105	2,704
Everett	...	280	2	2	...	...	...	...	284	5,629
Somerville	...	372	...	...	...	...	...	...	372	13,435
Totals	40	734	20	5	3	2	4	2	810	23,100

Summary of Services connected with Works, February 1, 1894.

	Charlestown.	Chelsea.	Everett.	Somerville.	Totals.
Number of services	6,083	5,487	2,974	7,854	22,398
Number of feet	162,796	147,217	59,707	266,339	636,059

Breaks and Leaks on Distribution-Pipes.

Size	2-in.	4-in.	6-in.	8-in.	10-in.	12-in.	16-in.	20-in.	30-in.	Totals.
Charlestown	3	. . .	. . .	1	. . .	. . .	. . .	1	1	6
Chelsea	. . .	19	6	. . .	4	. . .	. . .	. . .	. . .	29
Everett	1	7	2	1	1	. . .	. . .	. . .	. . .	12
Somerville	2	26	18	4	. . .	1	1	. . .	. . .	52

Distribution-Pipes Relaid.

Location.	Original Size.	4-in.	6-in.	8-in.	10-in.	12-in.	20-in.	Total.
Charlestown, Bunker Hill ct. . .	2-in.	149	. . .	. . .	. . .	. . .	. . .	149
Chelsea, Fourth st.	4-in.	. . .	304	. . .	. . .	. . .	. . .	304
" Ash st.	4-in.	. . .	66	. . .	. . .	. . .	. . .	66
" Washington ave.	6-in.	. . .	1,100	. . .	. . .	. . .	. . .	1,100
" Gardiner st.	4-in.	. . .	89	. . .	. . .	. . .	. . .	89
" Clark ave.	4-in.	. . .	34	. . .	. . .	. . .	. . .	34
" Eleanor st.	6-in.	. . .	310	. . .	. . .	. . .	. . .	310
" " "	4-in.	. . .	233	. . .	. . .	. . .	. . .	233
" Spencer ave.	4-in.	. . .	1,076	. . .	. . .	. . .	. . .	1,076
" Lynn st.	4-in.	. . .	490	. . .	. . .	. . .	. . .	490
" Watts st.	4-in.	. . .	28	. . .	. . .	. . .	. . .	28
" Winthrop st.	4-in.	. . .	355	. . .	. . .	. . .	. . .	355
" Webster ave.	6-in.	. . .	24	. . .	. . .	. . .	. . .	24
" Franklin st.	6-in.	. . .	460	. . .	. . .	. . .	. . .	460
" Hawthorn st.	4-in.	. . .	868	. . .	. . .	. . .	. . .	868
" Willard st.	4-in.	477	. . .	. . .	. . .	. . .	. . .	477
" Parker st.	4-in.	. . .	. . .	1,178	. . .	. . .	. . .	1,178
" Lafayette ave.	4-in.	. . .	. . .	90	. . .	. . .	. . .	90
" Clark st.	4-in.	. . .	. . .	1,550	. . .	. . .	. . .	1,550
" Second st.	4-in.	. . .	. . .	. . .	1,883	. . .	. . .	1,883
Everett, Oakland ave.	2-in.	. . .	517	. . .	. . .	. . .	. . .	517
" Corey st.	4-in.	. . .	12	. . .	. . .	. . .	. . .	12
" Second st.	6-in.	. . .	. . .	. . .	709	. . .	. . .	709
Somerville, Albion st.	4-in.	. . .	3	. . .	. . .	. . .	. . .	3
" Aldersey st.	4-in.	. . .	502	. . .	. . .	. . .	. . .	502
" Appleton st.	4-in.	. . .	563	. . .	. . .	. . .	. . .	563
" Bonner ave.	6-in.	. . .	. . .	20	. . .	. . .	. . .	20
" Boston st.	6-in.	. . .	20	. . .	. . .	. . .	. . .	20
" Cameron ave.	4-in.	. . .	4	. . .	. . .	. . .	. . .	4
" Chester st.	4-in.	. . .	641	. . .	. . .	. . .	. . .	641
" Clark st.	1-in.	. . .	. . .	170	. . .	. . .	. . .	170
" Clifton st.	4-in.	. . .	213	. . .	. . .	. . .	. . .	213
" Cottage ave.	4-in.	. . .	384	. . .	. . .	. . .	. . .	384
" Cutter ave.	4-in.	. . .	19	. . .	. . .	. . .	. . .	19
" Dane st.	6-in.	. . .	. . .	. . .	. . .	568	. . .	568
Carried forward	. . . .	626	8,315	3,008	2,592	568	. . .	12,517

Distribution-Pipes Relaid. — *Concluded.*

Location.	Original Size.	4-in.	6-in.	8-in.	10-in.	12-in.	20-in.	Total.
Brought forward	. . . .	626	8,315	3,008	2,592	568	. . .	12,517
Somerville, Day st.	4-in.	. . .	14	768	. . .	. . .	. . .	782
" Dover st.	4-in.	. . .	18	. . .	877	. . .	. . .	895
" Elm st.	4-in. } 6-in. }	. . .	42	. . .	. . .	1,990	. . .	2,032
" Franklin ave.	3-in.	485	. . .	. . .	. . .	. . .	. . .	485
" Frost ave.	4-in.	. . .	272	. . .	. . .	. . .	. . .	272
" Grand View ave.	4-in.	. . .	2	. . .	. . .	. . .	. . .	2
" Grove st.	4-in.	. . .	18	. . .	. . .	. . .	. . .	18
" Harrison st.	6-in.	. . .	30	. . .	. . .	. . .	. . .	30
" Heath st.	3-in.	. . .	5	. . .	. . .	. . .	. . .	5
" Hillside ave.	4-in.	149	. . .	. . .	. . .	. . .	. . .	149
" Herbert ave.	4-in.	. . .	376	. . .	. . .	. . .	. . .	376
" London st.	4-in.	. . .	4	. . .	. . .	. . .	. . .	4
" Meacham st.	4-in.	. . .	284	485	. . .	. . .	. . .	769
" Medford st.	4-in.	30	. . .	. . .	. . .	. . .	. . .	30
" No. Union st.	4-in.	. . .	442	. . .	. . .	. . .	. . .	442
" Oliver st.	4-in.	. . .	. . .	390	. . .	. . .	. . .	390
" Orchard st.	4-in.	. . .	. . .	. . .	529	. . .	. . .	529
" Pleasant ave.	4-in.	. . .	552	. . .	. . .	. . .	. . .	552
" Poplar st.	4-in.	17	. . .	. . .	. . .	. . .	. . .	17
" Sacramento st.	6-in.	. . .	142	. . .	. . .	. . .	. . .	142
" Summer st.	6-in.	. . .	. . .	. . .	62	. . .	. . .	62
" Summit ave.	4-in.	. . .	532	. . .	. . .	. . .	. . .	532
" Spring st.	4-in.	10	. . .	. . .	. . .	. . .	. . .	10
" Tenney ct.	4-in.	5	433	. . .	. . .	. . .	. . .	438
" Tower ct.	4-in.	173	. . .	. . .	. . .	. . .	. . .	173
" Tyler st.	4-in.	. . .	435	. . .	. . .	. . .	. . .	435
" Vinal ave.	6-in.	. . .	11	. . .	751	. . .	. . .	762
" Washington st.	8-in.	. . .	20	. . .	. . .	23	1,063	1,106
" Warren ave.	6-in.	. . .	673	. . .	. . .	. . .	. . .	673
" Willow ave.	6-in.	. . .	. . .	. . .	. . .	1,108	. . .	1,108
Total	. . . .	1,495	12,620	4,651	4,811	3,689	1,063	28,329

Extension of Distribution-Pipes.

Location.	2-in.	4-in.	6-in.	8-in.	10-in.	12-in.	16-in.	Totals.
Charlestown:								
Richards street	...	...	....	545	....	...	...	545
Riorden court	...	...	211	....	....	...	...	211
Bartlett street and Monument square	...	...	....	....	1,457	...	...	1,457
Hancock square	...	...	24	....	....	...	...	24
Chelsea:								
Parker street	...	18	....	....	....	...	...	18
Park avenue	...	...	80	....	....	...	...	80
Marlboro' street	...	...	243	....	....	...	...	243
Crest avenue	...	...	238	....	....	...	...	238
Everett avenue	...	...	702	....	....	...	...	702
Everett:								
Hazel park	...	264	....	....	....	...	...	264
Rich street	133	...	768	....	....	...	...	901
Marie street	...	...	620	....	....	...	...	620
Bennett street	...	...	160	....	....	...	...	160
Harris street	...	...	300	....	....	...	...	300
Glendale street	...	...	217	....	....	...	...	217
Gladstone street	...	...	572	....	....	...	...	572
Bailey street	...	...	490	....	....	...	...	490
Elm street	...	...	....	2,400	....	...	...	2,400
Tappan street	...	...	470	....	....	...	...	470
Waters avenue	...	...	396	....	....	...	...	396
Winslow street	...	...	255	....	....	...	...	255
Clark street	...	...	475	....	....	...	...	475
Valley street	...	...	459	....	....	...	...	459
Baldwin avenue	...	...	13	....	....	...	...	13
Glendale street	...	...	575	....	....	...	...	575
Buckman street	...	...	160	....	....	...	...	160
Orient street	...	...	250	....	....	...	...	250
Hadley court	...	...	205	....	....	...	...	205
Clifton avenue	...	168	....	....	....	...	...	168
Vine street	...	...	....	....	1,388	...	...	1,388
Carried forward	133	450	7,883	2,945	2,845	...	...	14,256

Extension of Distribution-Pipes. — *Continued.*

LOCATION.	2-in.	4-in.	6-in.	8-in.	10-in.	12-in.	16-in.	Totals.
Brought forward	133	450	7,883	2,945	2,845	...	...	14,256
Russell court	157	...	....	....	....	...	...	157
Boston street	...	...	....	....	276	...	...	276
Somerville:								
Albion street	...	...	30	....	....	...	...	30
Ames street	...	...	36	....	....	...	...	36
Atherton street	...	...	....	298	....	...	...	298
Banks street	...	...	....	106	....	...	...	106
Benton avenue	...	...	....	133	....	...	...	133
Billingham street	...	...	30	....	....	...	...	30
Broadway	...	21	....	....	....	128	...	149
Burnside avenue	...	...	....	313	....	...	...	313
Charnwood road	...	...	634	....	....	...	...	634
Clarendon avenue	...	262	224	....	....	...	...	486
Cottage avenue	...	...	207	....	....	...	...	207
Cypress street	...	...	18	....	....	...	...	18
Dell street	...	...	132	....	....	...	...	132
Elston street	...	...	....	13	....	...	...	13
Elm street	...	...	....	....	....	200	...	200
Elmwood street	...	...	....	48	....	...	...	48
Frost avenue	...	...	320	....	....	...	...	320
Gilman square	...	...	106	....	....	...	...	106
Glover circle	...	...	118	....	....	...	...	118
Gordonia road	...	...	212	....	....	...	...	212
Grove street	...	...	....	200	....	...	...	200
Hall avenue	...	...	6	339	....	...	...	345
Hancock street	...	...	6	185	....	...	...	191
Harrison street	...	...	382	....	....	...	...	382
Hawthorne street	...	...	26	....	....	...	...	26
Harvard avenue	...	...	120	....	....	...	...	120
Hillside avenue	...	16	....	....	....	...	...	16
Mansfield street	...	...	13	....	....	...	710	723
Melvin street	...	...	....	171	....	...	...	171
Mandomin court	...	8	....	....	....	...	...	8
Mousal place	...	...	12	....	....	...	...	12
Carried forward	290	757	10,515	1,816	3,121	328	710	20,372

Extension of Distribution-Pipes. — *Concluded.*

LOCATION.	2-in.	4-in.	6-in.	8-in.	10-in.	12-in.	16-in.	Totals.
Brought forward	290	757	10,515	1,816	3,121	328	710	20,372
Mt. Vernon avenue	. . .	5	. . . .	. . . .	. . . .	. . .	. . .	5
Mystic avenue	. . .	10	334	. . . .	. . . .	. . .	. . .	344
Mystic street	. . .	. . .	. . . .	43	. . . .	. . .	. . .	43
Oliver street	. . .	. . .	10	. . . .	. . . .	. . .	. . .	10
Prospect street	. . .	. . .	. . . .	. . . .	. . . .	. . .	166	166
Rossmore street	. . .	. . .	42	. . . .	. . . .	. . .	. . .	42
Russell street	. . .	. . .	260	. . . .	. . . .	. . .	. . .	260
Summer street	. . .	. . .	. . . .	. . . .	233	. . .	. . .	233
Stone avenue	. . .	. . .	154	. . . .	. . . .	. . .	. . .	154
Talbot street	. . .	. . .	10	561	. . . .	. . .	. . .	571
Washington street	. . .	. . .	20	. . . .	. . . .	. . .	. . .	20
West street	. . .	. . .	223	. . . .	. . . .	. . .	. . .	223
Wigglesworth street	. . .	. . .	188	. . . .	. . . .	. . .	. . .	188
Windom street	. . .	. . .	14	. . . .	. . . .	. . .	. . .	14
Totals	290	772	11,770	5,355	3,354	328	876	22,745

Length of Distributing-Mains connected with Works, February 1, 1894.

	Diameter.												
	3-in.	4-in.	6-in.	8-in.	10-in.	12-in.	14-in.	16-in.	18-in.	20-in.	24-in.	30-in.	36-in.	Totals.
Charlestown . . .	2,436	25,033	64,386	22,951	7,063	15,087	. . . . .	20,140	. . . . .	6,180	16,982	25,296	974	206,528
Chelsea	18,313	68,788	47,179	10,605	28,536	. . . . .	. . . . .	2,348	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	175,769
Everett	914	53,164	70,732	7,330	9,501	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	141,641
Somerville	6,965	83,123	174,406	44,316	13,720	13,171	8,037	996	387	1,063	. . . . .	. . . . .	. . . . .	346,184
Totals	28,628	230,108	356,703	85,202	58,820	28,258	037	23,484	387	7,243	16,982	25,296	974	870,122

Number of Gates connected with Works, February 1, 1894.

Charlestown . . .	13	169	219	59	19	38	. . . . .	25	. . . . .	4	11	12	. . . . .	569
Chelsea	30	184	84	25	22	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	345
Everett	18	105	203	18	15	2	. . . . .	. . . . .	. . . . .	2	. . . . .	. . . . .	. . . . .	363
Somerville	5	217	336	41	28	30	. . . . .	2	. . . . .	1	. . . . .	. . . . .	. . . . .	660
Totals	66	675	842	143	84	70	. . . . .	27	. . . . .	7	11	12	. . . . .	1,937

Hydrants Established.

	Established.				Net Increase.
	Lowry.	Boston Lowry.	Post.	Flush.	
Charlestown	4	.....	.....	.....	4
Chelsea	.....	.....	10	.....	10
Everett	.....	.....	36	.....	36
Somerville	.....	.....	33	.....	33
Totals	4	.....	79	.....	83

Total Number of Hydrants in use February 1, 1894.

Charlestown	202	33	58	38	331
Chelsea	.....	.....	198	2	200
Everett	1	.....	201	.....	202
Somerville	2	.....	560	.....	562
Medford	.....	.....	2	6	8
Pumping-station	.....	.....	2	1	3
Totals	205	33	1,021	47	1,306

Respectfully submitted,

EUGENE S. SULLIVAN,
Superintendent.

REPORT OF THE ENGINEER.

ENGINEERING DEPARTMENT,
50 CITY HALL, February 1, 1894.

COL. THOMAS F. DOHERTY,
Chairman Boston Water Board:

SIR: I hereby submit the following report of the work done and records kept during the past year, for your Board:

CORROSION OF PIPES BY ELECTROLYSIS.

During the year 1892 a number of leaks in lead service-pipes were found which were caused by electrolytic action due to underground currents of electricity induced by the street-railway system.

The pipes were decomposed on the exterior surface and presented a pitted appearance. Most of the cases were discovered in the immediate vicinity of the power-station of the West End Railroad Company, where the quantity of current is naturally largest.

As the use of electricity for motor power is constantly increasing, and as the destruction of our water mains and services would be of incalculable injury to our city, an investigation has been begun into the causes and extent of the difficulty, with the view of taking the necessary measures to preserve the pipes, both lead and iron, from further injury. This investigation has been placed in the hands of Messrs. Stone & Webster, electrical engineers, and the results of their preliminary study indicate that decomposition of the pipes is going on, but that, generally, it may not be apparent for some years.

The cases which have so far been discovered have been where the quantity of electricity in the ground was large; but we have no proof that the same action is not taking place more slowly all over the city. The investigations show that there is a constant current of electricity flowing through the earth toward the power-station, and that the intensity of the current varies continually with the amount of power used. As these currents must unavoidably pass into and out of the water-pipes by way of the earth, and as electrolytic action follows in a greater or less degree, it is more than probable that the gradual decomposition of our pipes is taking place.

Whether this corrosion of decomposition is sufficient to seriously affect the pipe system has not yet been determined, and I recommend that the investigations be continued during the present year. I would also recommend that test-pits be dug for the examination of the pipes in different parts of the city, particularly in the immediate vicinity of the West End power-station, and if evidence of corrosion of the pipes is discovered I would recommend that the pipes be drained by means of heavy copper conductors connected with the power-station.

The following is a preliminary report from Messrs. Stone & Webster:

BOSTON, January 31, 1894.

WILLIAM JACKSON, Esq., *City Engineer:*

SIR: In accordance with your request we have entered upon a careful investigation of the subject of the corrosion of water pipes and mains by electrolysis, and beg to submit the following preliminary report:

A longer time for experimental work, and a season of the year at which the pipes are more freely accessible, are necessary to place us in a position to report fully on the extent of the difficulty, and to make definite recommendations as to its remedy.

This report presents briefly to your consideration the following points, and contains an appendix which includes various data obtained by us, together with a somewhat detailed discussion of the same.

The points considered in this report are as follows:

First. The evidence showing injury by corrosive electrolysis to underground iron and lead piping for water, gas, and telephone cables in Boston and elsewhere.

Second. The nature of this injury to pipes as developed by experimental tests in the laboratory.

Third. The existence of the necessary conditions, electric and otherwise, in the soil of Boston, to produce electrolysis in pipes laid therein.

Fourth. The proof that these electric conditions are due to the return currents by way of the earth, arising from the electric service of the West End Street Railway Company.

From these we shall show that the inference that serious corrosion may be proceeding from this cause is almost unavoidable, while, however, distinctly pointing out that the evidence is still insufficient for decisive judgment.

Finally, while we are not yet prepared to suggest a practicable and complete remedy, we shall point out methods by which the trouble has been somewhat lessened in certain instances.

The Evidence of Injury.

The action of electrolysis is to corrode the pipes, chiefly at the surfaces where the electric current leaves them. This corrosion is not uniformly distributed over the surface, but is quite irregular, usually producing deep pits. Its tendency is, therefore, to accelerate the natural rate of decay of the pipes, the rate of corrosion being greater as the current flowing out of the pipe is greater.

The evidence of injury to water and gas mains by electric action would, therefore, naturally be expected to take two forms: one, the

very premature giving out of pipes in localities where the conditions were such that especially large currents flowed out from the surface of the pipes; the other, the increase of rate of renewals and repairs in the entire system, so far as exposed to the electric currents.

Evidence of the first sort would presumably be the earliest to develop itself, and we shall quote some instances. Evidence of the second sort would appear only in the course of years, and the evil might have assumed serious proportions before this class of evidence became convincing. We have been able to secure very little such evidence.

It should be clearly apprehended that the injury to the pipes, if going on at all, is of a very insidious character, consisting, as stated, merely in an acceleration of the natural decay of the pipes. This acceleration might be seriously large and yet not become apparent for a term of some years, when the trouble would suddenly begin to assume very large proportions. The absence of extensive direct evidence of destruction must not, therefore, be interpreted as proving the absence of the action. The amount of direct evidence, although not yet large, is sufficiently disquieting.

Of actual giving out of water-pipes in Boston, apparently through electrolysis, the only instances which we are able to cite are those of lead service-pipes in the vicinity of the power-station of the West End Street Railway Company on Albany street. At the time that these pipes were discovered, the subject was not under careful investigation, and the reasonable supposition that electric currents played a considerable part in their destruction was not put to test by critical inspections.

Of the destruction of lead piping in general by electrolytic action underground, we have abundant and indisputable evidence in the corrosion of the lead sheaths of telephone cables. In one case, the sheath of a new cable was destroyed within six weeks of laying. The amount of the injury, its nature, and the methods successfully adopted for its partial removal, show conclusively that it was due to electric currents traversing and escaping from the lead covering on their way between the electric cars and the power-station of the West End Street Railway Company, in the same way that they presumably do from water-pipes.

From several cities other than Boston, owing possibly to more favorable conditions for the development of trouble, injury of a serious nature has been reported respecting water and gas mains. We have information, reliable in character, showing electrolytic injury of water-pipes in Peoria, Ill., and Cambridge, Mass., and of iron mains in Norwalk, Conn., — the trouble being serious in all cases.

Pipe-Tests.

In order to get an idea of the probable character of the electrolytic action upon the water-pipes and the rapidity with which it might be taking place, a number of tests were made at our laboratory upon commercial specimens of pipe, under conditions similar to those to which the city piping is exposed.

The pipes were grouped in pairs as shown by the table of pipe-tests, and each pair in a separate box of moist sand sprinkled with a small quantity of common salt.

In this respect they were practically under the conditions of pipes buried in the streets, since the moist earth usually contains common salt and other salts either from the tide water or from the surface drainage.

Measured currents of electricity at constant pressure were then caused to flow for noted times from one pipe to the other of a pair. Thus one pipe would show the action when the current flowed out of the pipe into the earth (*i.e.*, when the pipe was electrically positive with respect to

the earth around it) ; the other would show the effects when the current flowed from the earth into the pipe (*i.e.*, when the pipe was negative relatively to its surroundings).

The common salt in the water by its electrolysis yields chlorine at the surface where the current of electricity leaves the pipe. This corrodes the pipe rapidly. At the surface where the current enters the pipe th product formed by the electrolysis has but little corrosive action.

This well-known fact was borne out by these experiments, which developed, moreover, a point of great practical importance; namely, that the corrosion took place largely in a localized manner. That is, the pipes became deeply pitted in spots instead of corroding uniformly over the surface.

Although the difference of potential between every pair was the same, the currents were of various magnitudes corresponding to the degree of moisture and quantity of salt in solution.

Consequently, this must be taken into consideration, in comparing the effect of electrolysis on pipes in different boxes; for with pipes of the same material, the losses are directly proportional to the magnitudes of the currents. After reweighing at the end of 100 hours, the tests were continued for 50 hours more on all the specimens except Nos. 13 and 14.

The positive pipes were all badly pitted, so that the amount lost as determined by weighing before and after the run is not a true measure of their deterioration.

To make this more evident, pipe No. 13, which had lost but 7.6 per cent. in weight, was turned down for half its length, to the bottom of the deepest pit, and the loss in weight was then found to be, for the whole pipe, 63 per cent. This shows, of course, that owing to the formation of pits the corrosion has gone in spots to about eight times the depth that it would have gone if it had been uniform over the surface.

This is a true measure of the electrolytic action, for the strength of a pipe is determined by the strength at its thinnest part, which leaves the pipe but 37 per cent. of its original value.

Tarred Wrought-Iron Pipe No. 13.

Length	1 foot
Diameter	1 inch
Original weight	694.7 grams
Loss of weight after 100 hours	53.2 "
Average current	0.739 amp.
Average voltage	12.96 volts
Weight of iron turned off in ½ length	191.9 grams
Weight of iron pipe equivalent to pipe in present condition	257.7 grams
Present value in per cent. of original	37 per cent.

After running one hundred and fifty hours. four other iron pipes, Nos. 1, 5, 9, and 11, were similarly treated, and the results tabulated below. The positive lead pipes were all so deeply pitted that it was impossible to turn them down. They showed even more marked deterioration, however, than the wrought-iron pipes.

Table showing True Extent of Deterioration caused by Electrolysis.

Number of pipe	1	5	9	11
Length	1 ft.	1 ft.	1 ft.	1 ft.
Diameter	2 in.	1 in.	1 in.	1 in.
Original weight in grams	1,565.3	693.0	638.0	695.0
Loss of weight in 150 hours	39.7	172.8	202.2	129.2
Average current	0.253	1.420	1.472	0.946
Average voltage	12.37			
Weight of pipe equivalent to pipe in present condition	850.6	169.6	199.6	161.2
Present value in per cent. of original	54.3	24.5	31.3	23.2

In these tests data have been accumulated which may prove of further value later in a discussion of the relative merits of different kinds of piping, but which we are not now prepared to enter upon.

In the experiments, in order to save time, it was necessary to use currents of electricity larger than could be expected to occur, except under unusual conditions, in practice. This, however, does not affect the general character of the electrolytic action, but only its rate, the amount of electrolysis being proportional to the current.

The corrosion and disintegration of the sheaths of the telephone cables by electrolysis underground was of the same general character as that in the lead pipes tested in the laboratory.

Existence of Necessary Condition for Electrolysis.

If we could ascertain by direct means whether currents of electricity were flowing from the earth into the pipes or from pipes to earth, how large these currents were, and how they were distributed over the pipe surface, we should then have a direct means of estimating the injury done to the pipes; but these three points are from the nature of the case very difficult, if not impossible, of even rough determination. It is essential, therefore, to proceed indirectly by showing that the underground electrical conditions in the city are such as either to render destructive electrolysis likely, or to render it unlikely. We have done so as follows:

By extended tests we have shown that the distribution of electrical pressure in the earth in Boston is such that there must be a continual and at times strong flow of electricity through the earth from nearly all parts of the city toward the West End Power-Station on Albany street.

Inasmuch as iron water and gas mains are imbedded broadcast in the soil, and are relatively much better conductors than the soil, bulk for bulk, a portion of these currents must traverse the pipes; and since there is no metallic connection between the pipes and the railway returns, the current must enter and leave the pipes by way of the earth. Wherever the current thus enters or leaves a pipe it is accompanied by electrolysis at that point, the amount of the electrolysis being proportional to the current. This produces corrosion, but chiefly where the current leaves the pipe.

Admitting, then, the conclusion just drawn that currents must enter and leave the pipes, and since this process is nearly continuous throughout the day, the inference is unavoidable that corrosion is continually going on, and in the same measure as the current. This inference is confirmed by multiplied tests, which show that the piping is almost everywhere at a potential different from the earth around it, and from the nearest railway tracks.

Under such conditions currents must be flowing either to or from the

pipes. These differences are, moreover, not constant, but subject to continual momentary fluctuation, which add to the certainty of the flow of currents.

The demonstration of the continual flow of current through the earth to the power-station was made by measuring the difference between the electrical pressure in the water-piping at a point near the station, and at other distributed points. These outlying points showed always higher pressures than the one near the station. The difference amounted in one case to more than 15 volts in 4,000 feet. Similar measurements were made between the outlying points themselves.

It is evident that by taking a sufficient number of points and of pressure observations between them, an equipotential map — that is, a map showing lines of equal pressure difference relatively to the power-station — might be drawn; but while such a map would possess some value, we have not yet thought ourselves justified in incurring the expense of running the necessary number of overhead lines in the city.

It is, perhaps, not superfluous to add that the substances which give the soil its conductivity are chiefly the various salts which are in solution in the water of the soil. Earth itself, when perfectly dry. is a very poor conductor; water when pure is also an exceedingly bad conductor. Moist earth is usually a comparatively good conductor, not, however, because of the conductivity of the water itself, but because the water holds in solution common salt and other salts which make it a conductor, these being derived either from the soil, from surface drainage, or from the sea, much of the soil beneath Boston being moistened by tide water.

There are, therefore, present in the soil of Boston not only the electric current necessary to produce electrolysis, but the materials which will upon electrolysis produce corrosion of iron and lead.

Cause of the Underground Electric Current.

The above-mentioned measurements of pressure-difference between various points afford convincing proof that these pressures are due almost exclusively to the return currents of the West End Street Railway. For not only are the pressures found to be distributed about the power-station in the way which would be anticipated, but they show fluctuations from hour to hour, and even minute to minute throughout the day, which, when plotted as curves, show the characteristic form of the power load at the station, being nearly zero in the early morning hours, and having four maxima; namely, at about 8 A.M., 6, 8, and 11 P.M. This point is very clearly illustrated by tests made on January 3d and 4th, 1894, to show the difference of potential between the water-pipes at different points in the city. By means of rubber-covered copper wires the water-pipes at Foster's wharf and Summer street were connected with the water-pipes at the corner of Harrison avenue and Bristol street, near the power-station of the West End Street Railway.

Continuous readings of the difference in potentials were taken for 24 hours, and the results show admirably the periodic fluctuations corresponding to the amount of travel on the railroad. (See plates 1 and 2.)

If any evidence of the source of these currents and pressures were necessary, this would be incontestible.

Summary.

It seems from the preceding discussion that the direct evidence is good, although not yet ample; that injury has been wrought upon iron and lead pipes buried in the earth; this injury being the direct result of corrosion arising from the passage of the return currents of an electric street-railway into or out of the pipes.

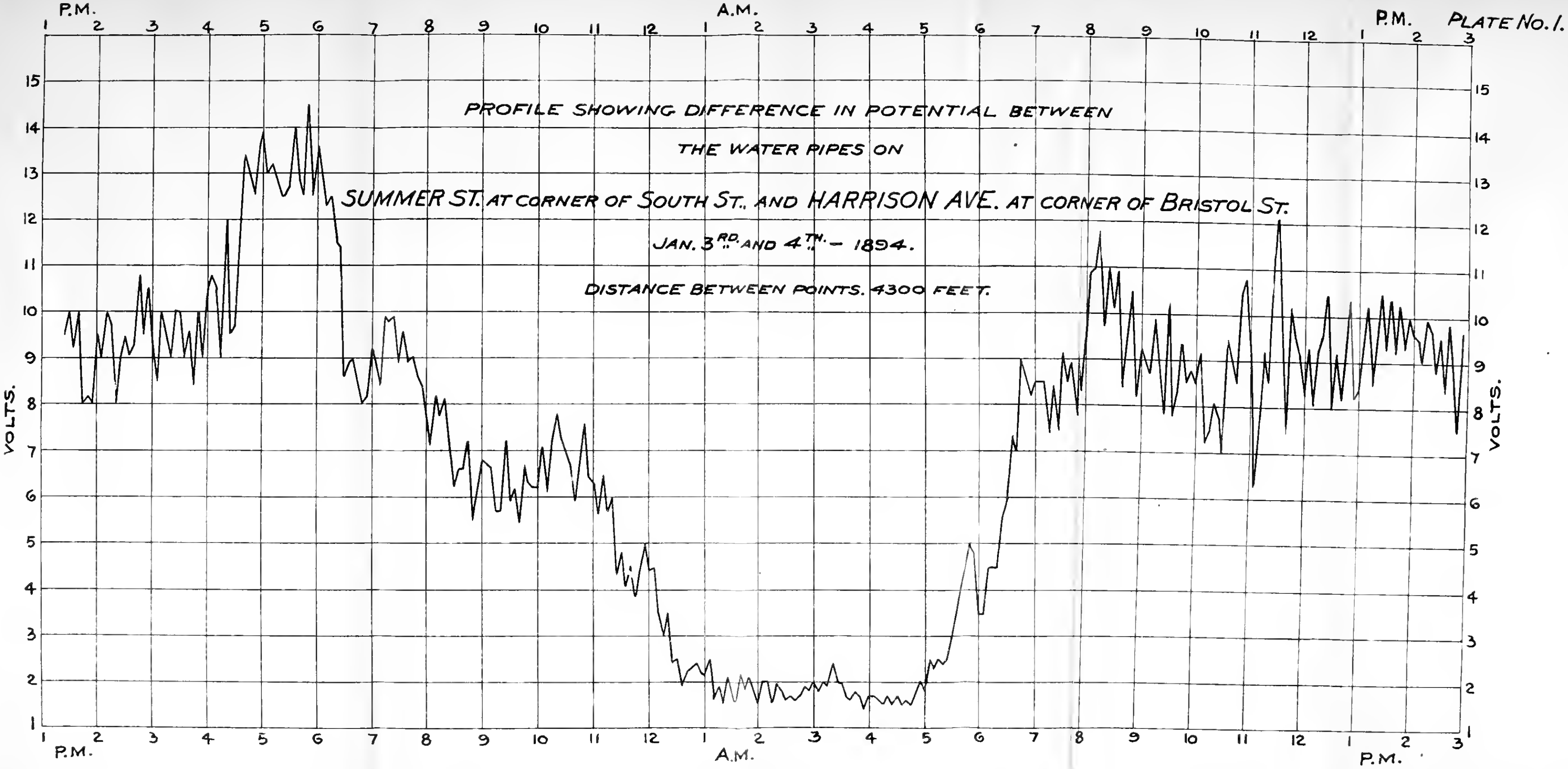
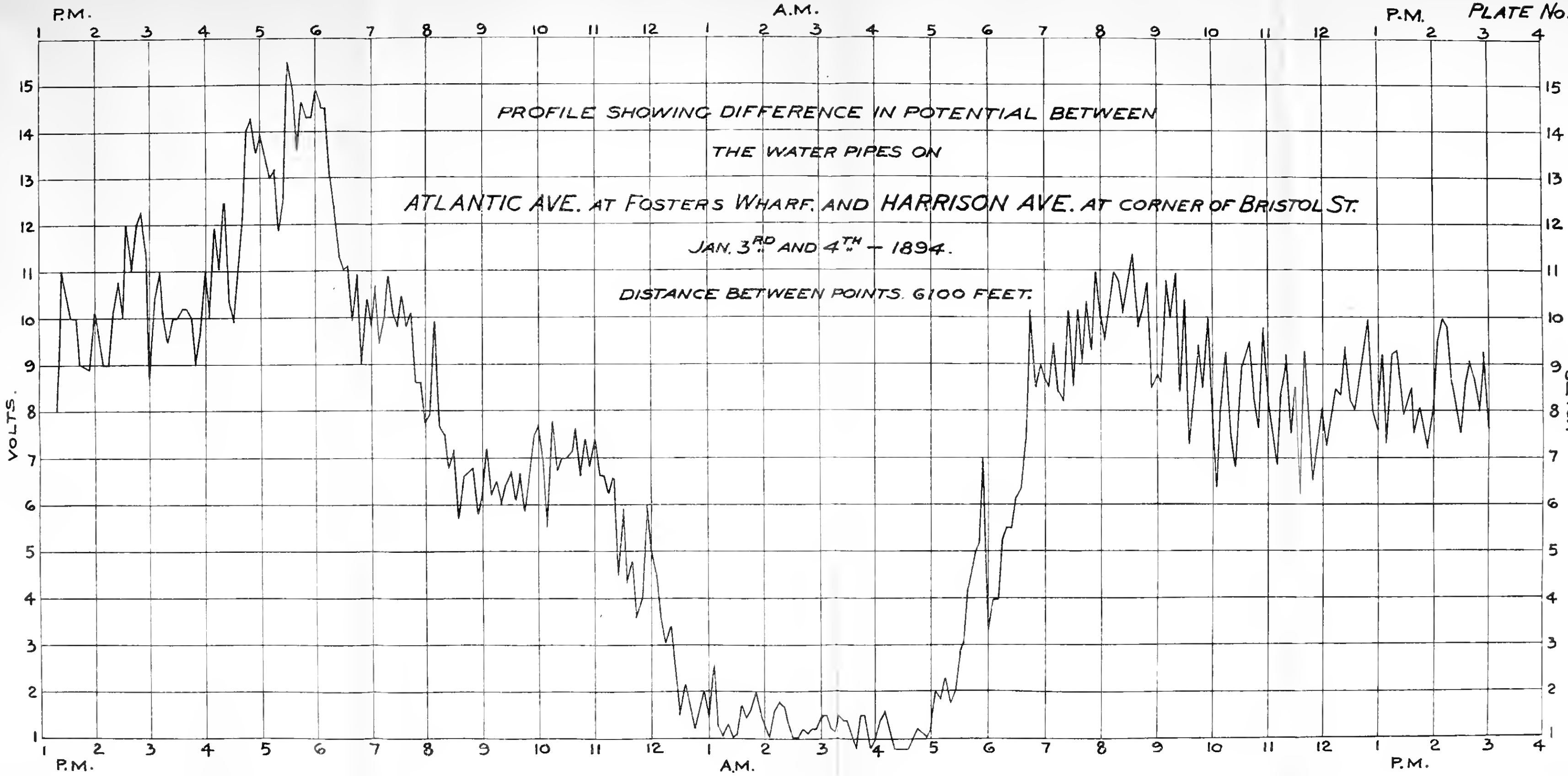
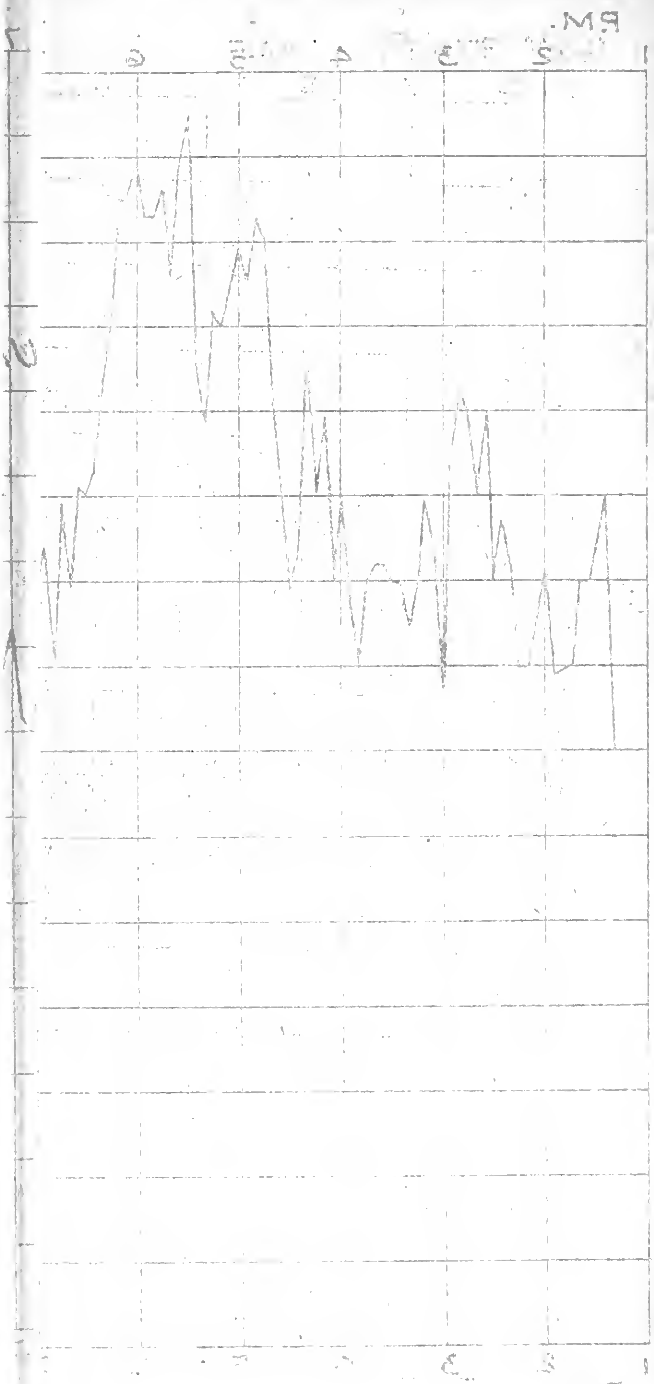


PLATE No. 1.
PROFILE SHOWING DIFFERENCE IN POTENTIAL BETWEEN
THE WATER PIPES ON
SUMMER ST. AT CORNER OF SOUTH ST., AND HARRISON AVE. AT CORNER OF BRISTOL ST.
JAN. 3RD. AND 4TH. - 1894.
DISTANCE BETWEEN POINTS. 4300 FEET.
P.M.
A.M.
P.M.
VOLTS.
VOLTS.

PLATE No. 2.



PROFILE SHOWING DIFFERENCE IN POTENTIAL BETWEEN
THE WATER PIPES ON
ATLANTIC AVE. AT FOSTERS WHARF. AND HARRISON AVE. AT CORNER OF BRISTOL ST.
JAN. 3RD AND 4TH — 1894.
DISTANCE BETWEEN POINTS. 6100 FEET.
P.M.
A.M.
P.M.
VOLTS.
VOLTS.



It seems further to be almost incontestably shown that the underground conditions in Boston are such that electric currents, presumably of considerable magnitude, pass into and out of the pipes by way of the earth, and with the unavoidable accompaniment of electrolysis and corrosion.

It remains to be shown whether this corrosion is or is not, under existing conditions, a serious factor in lessening the life of the piping system as a whole or of any part of it in particular.

Upon this most important subject we feel that the points previously made in this report would certainly not warrant a hopeful view. They would rather incline one toward the opinion that serious corrosion may be now proceeding; but we must strongly call attention to the fact that it has been impossible, thus far, to acquire sufficient reliable information to warrant a decision.

The matter is under further investigation.

Remedy.

As to remedy it is clear, of course, that were the return railway circuit to be confined to channels provided for it, the trouble would cease. This it is impossible to do with a railway system in which the cars give up their return current to the uninsulated rails as now. However good the conductivity of the copper return lines provided, the current will divide between them and the earth, the fraction going back by earth being to that going back by the copper lines as the earth conductivity is to that of the lines. Now, the earth conductivity is at least fairly good, so that the amount of copper required in returns becomes enormous to reduce the earth currents to small amounts. Railway systems which do not ground the return have not proved successful for various reasons.

To remove the difficulty with telephone cables, the New England Telephone & Telegraph Company has laid a special copper return along the affected part of the cable, and thence by a heavy overhead line back to the power-house. This, together with the practice by the West End Street Railway Company of making the trolley-wire positive, has proved largely successful.

It is feasible because the number of these cases to be dealt with is comparatively small, so that the expense is not intolerable.

A similar suggestion respecting certain portions of the water-main system was offered by us in February, 1893.

The larger and better distributed such a system of special copper return from the water-pipes is, the less danger from electrolysis; but the great outlay for copper involved is prohibitive beyond a certain limit. Whether within this limit the electrolysis can be reduced to an unimportant amount is by no means yet demonstrated. The data is still so incomplete as not to warrant a positive inference.

(Signed) STONE & WEBSTER.

SOURCES OF SUPPLY.

The rainfall during the year 1893 was above the average of the last twenty years, but on account of the unequal distribution of the rainfall the amount of water in store in the reservoirs was reduced to a smaller amount than during any year since the Sudbury-river works have been in use.

The rainfall and quantities collected on the several water-sheds were as follows:

	Sudbury.	Cochituate.	Mystic.
Rainfall in inches .	48.225	45.28	44.20
" collected in inches .	21.774	17.65	19.687
Daily average yield of water-shed in gallons . .	77,963,300	15,862,000	25,192,500

The quality of the water has continued to be good, the only noticeable change being in an increase in color of the water of the Sudbury and Cochituate supply. This has been caused by the use of a larger proportion of Sudbury-river water.

Reservoir No. 1.— With the exception of a few days during the first week of January, no water was wasted over the dam until February 8.

Water flowed over the crest of the dam continuously from this time until June 6, when waste ceased and the amount passing the dam from the latter date to January 1, 1894, has been only the daily flow of one and one-half million gallons required by law.

The lowest point reached by the reservoir was 155.11, or 4.18 feet below the top of the flash-boards on November 27, 1893.

Reservoir No. 2. — The water in this reservoir remained at or near high-water mark until the first of July. During the month of July the water surface was lowered nearly seven feet, and in the months of August and September it was from five to six feet below high-water mark. In October and November the quantity in store was still further reduced, and on December 1 the water was 12.7 feet below high water, the lowest point reached during the year.

Reservoir No. 3.— This reservoir was drawn down to 8 feet below the crest of the dam during the month of January, but on February 13 water began to waste over the dam and continued until the first of June.

Water was taken from this reservoir for the supply of the city from May 24 to August 3, and at the latter date the surface of the reservoir was 17.89 feet below the crest of the dam.

It was again drawn upon on September 26, and on October 23 the reservoir was practically empty. It remained empty until December 1, when it began to fill, and on February 1 the water-surface was 2.68 feet below the crest of the dam.

Reservoir No. 4. — On January 1, 1893, the water in Reservoir No. 4 was 20.99 feet below high-water mark. On March 23 the reservoir was full and water began to waste at the overflow.

The reservoir was kept full until August 3, when the gates were opened, and during August and September 1,293,800,000 gallons were drawn from the reservoir for the supply of the city, lowering the water in the reservoir 35 feet. The outlet gates were closed from September 26 to October 27, when they were again opened, and on November 17 the reservoir was emptied.

The outlet gates have been closed since December 6, and at the present time, February 1, the water surface is 29.45 feet below high-water mark.

Farm Pond. — The average height of the water in this pond has been 148.82 feet above tide-marsh level, and the surface has not varied more than 11 inches from that height during the year.

The Framingham Water Company has drawn from the pond 103,000,000 gallons.

Lake Cochituate. — Lake Cochituate was about six feet below high-water mark on January 1, 1893, and did not fill until April 22.

A small quantity of water was wasted at the outlet dam in May, and about June 1 the lake began to fall. There was a gradual lowering of the water surface from June 1 to October 27, when it was 6.6 feet below high-water mark, and it remained at about the same level during the months of November and December.

In October the water in the lake was but little above the top of the aqueduct, and for the purpose of maintaining the supply to the city in case of a continued drought, a temporary pumping plant was erected at the gate-house capable of pumping 20,000,000 gallons per day into the aqueduct. The engines and pumps were placed in position, housed, and put in readiness for use, but the lake did not fall so as to require their use.

For the purpose of purifying the water of Pegan brook before it enters the lake, three filter-beds have been built near the mouth of the brook, into which the water of the brook is pumped and allowed to percolate through the sand into the lake. The beds have a combined area of about 4 acres, and are from 6 to 12 feet above the surface of the lake. They are surrounded by banks 5 feet high, and the two upper beds have underdrains of 8-inch vitrified pipe, laid about 100 feet apart, at a depth of 8 feet below the surface of the beds.

For the purpose of retaining the water of the brook, a dam 8 feet in height was built, having a centre of 4-inch tongued and grooved sheet piling, upon which a centre wall of concrete was built.

The embankment is of gravel 10 feet wide on top, with slopes of two horizontal to one vertical. The water is pumped on to the beds by means of a 25-horse power Hoadly engine, and two 6-inch centrifugal pumps delivering the water through about 1,000 feet of 12, 8, and 6 inch pipe. The cost of construction exclusive of land damages was $12,585.11. The works have been in operation since June 25, but from September 11 to November 3 no water was pumped, as the flow of the brook was so small that it percolated through the dam or evaporated.

Dudley pond was drawn off to reinforce the lake during the month of November.

No water has been received in the lake from the Sudbury river during the year.

Water has been drawn from the different reservoirs as follows:

RESERVOIR NO. 1.

February 10 to April 13, inclusive.

December 2 to 31.

RESERVOIR NO. 2.

May 23.

August 4 to 20.

August 22 to September 14.

September 16 to 25.

RESERVOIRS NOS. 2 AND 3.

January 1 to February 9.

April 14 to May 11.

May 13 to 21.

May 25 to August 3.

September 26 to December 1.

The heights of water in the various storage reservoirs on the first day of each month are given below.

	Reservoirs.				Farm Pond.	Lake Cochituate.
	No. 1.	No. 2.	No. 3.	No. 4.		
	Top of Flash-boards.	Top of Flash-boards.	Crest of Dam.	Crest of Dam.	High Water.	Top of Flash-boards.
	159.29	167.12	175.24	215.21	149.25	134.36
January 1, 1893	157.44	163.04	171.58	194.22	148.63	128.41
February 1, "	157.31	159.46	167.05	197.04	148.75	127.58
March 1, "	157.76	166.08	175.50	204.64	149.28	129.50
April 1, "	158.15	166.12	175.52	214.62	149.31	133.38
May 1, "	147.83	166.11	175.54	214.44	149.50	134.51
June 1, "	146.93	167.17	175.37	214.81	148.89	134.12
July 1, "	156.40	166.46	174.02	215.05	148.85	133.24
August 1, "	156.43	160.17	168.02	215.07	148.50	131.68
September 1, "	156.20	161.55	167.79	201.42	148.53	130.60
October 1, "	155.57	161.45	166.21	179.72	148.31	128.95
November 1, "	155.40	157.50	158.65	179.77	148.39	128.30
December 1, "	155.16	155.30	158.20	170.51	148.39	127.58
January 1, 1894	155.55	160.17	168.53	178.83	148.74	127.94

Aqueducts and Distributing Reservoirs.

The Sudbury-river aqueduct has been used 361 days, and has delivered 11,737,900,000 gallons into the Chestnut Hill and Brookline reservoirs. The Cochituate aqueduct has been used 356 days, and delivered 5,623,532,500 gallons.

The distributing reservoirs are in good order. The overflow at the East Boston reservoir, which was constructed of flagging and brick, and was badly cracked by settlement or frost, has been replaced by a 12-inch pipe thoroughly embedded in Portland cement concrete.

Reservoir No. 6.

This reservoir, which has been in process of construction during the past four years, has been practically completed, and is now being filled. It is situated on Indian brook in the towns of Ashland and Hopkinton, and has a capacity of about 1,500,000,000 gallons.

The dam across the valley is about 1,500 feet in length, and consists of an earth embankment with a centre core wall of concrete extending to the bed rock. This core wall is 8

feet in thickness at the base, and 3 feet at the top, and is plastered on its upstream side with a very carefully applied coating of Portland cement one-half inch in thickness. A thick coating of Portland cement mortar, mixed in the proportion of one part cement to one part of sand, was put on to the concrete, rubbed to a uniform thickness and left rough. Over this was smoothly spread with trowels a coat of neat Portland cement, which was thoroughly worked in order to make a perfectly water-tight surface.

The embankment is 20 feet wide on top. The inner or reservoir slope is two horizontal to one vertical, with a berme 6 feet in width 13 feet below the top of the embankment. This slope is riprapped below the berme, and from the berme to the top of the embankment is paved. The outer slope is covered with loam, and has a gutter running longitudinally about half-way down its face to prevent washing of the banks by rain. Above this gutter the slope is 2 to 1, and below 2½ to 1.

The body of the embankment is composed of sand and gravel, deposited in thin layers, watered, and well compacted by rolling. Next the core wall, on the upstream side, the material was selected so as to aid in securing a water-tight dam.

Two gate-houses have been constructed in the dam in which the delivery pipes are so arranged that the water can be drawn from different levels, and if desired discharged into filter beds.

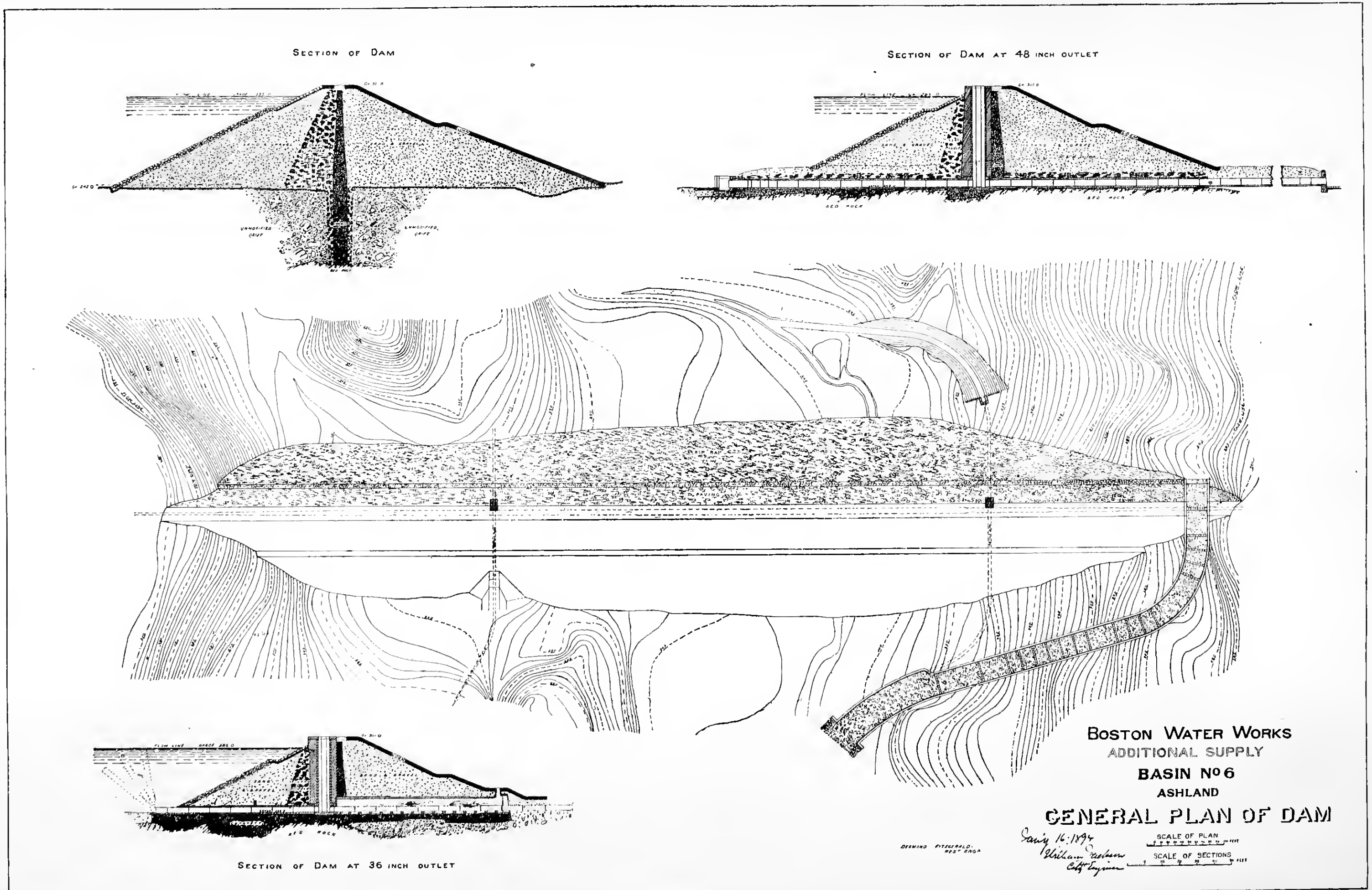
For further information concerning work on this reservoir and other work in connection with additional supply, see the following report of Desmond FitzGerald, Resident Engineer:

SOUTH FRAMINGHAM, MASS., January 1, 1894.

WILLIAM JACKSON, Esq., *City Engineer:*

DEAR SIR: I submit herewith a brief report of engineering work accomplished during the past year by the Additional Supply force.

At Basin No. 6 the building of the core wall was resumed on May 1, and on May 10 the first gravel was delivered. The dam was built up from grade 270 to the top, by the end of the year, and is practically completed, although the paving is not yet done. The riprap extending from the berme to the inner toe is in place, and the broken stone above the berme, forming the footing-course for the paving, has been placed so that the basin can now be filled. The contract for laying the riprap and paving was awarded to John Berry on September 19. The removal of the loam from the basin


Section of Dam
Section of Dam at 48 inch outlet
Section of Dam at 36 inch outlet
Boston Water Works
Additional Supply
Basin No 6
Ashland
General Plan of Dam
Scale of Plan
Scale of Sections
Desmond FitzGerald
Res. Engr.
Jan'y 16, 1894
William Jackson
City Engineer

and the treatment for shallow flowage were completed before the end of the season. October 2 a small section of stripping, remaining near the dam, was let to A. Saucier.

The loam for the Boston Park Department was all removed, and the tracks taken out of the basin.

Mr. N. S. Brock, Assistant Engineer, has had charge of Basin 6.

WORK DONE AT BASIN 6 IN 1893.

5,564	cubic	yards	concrete.
4,196	square	"	cement plaster.
104,170	cubic	"	embankment.
20,000	"	"	stripping.
3,670	"	"	stone crushed.
1,574	"	"	sand screened.
4,522	"	"	riprap.
1,504	"	"	ballast.
12,000	"	"	loam hauled.

Gravel for the embankment was taken this year from a new gravel pit on the westerly side of the basin.

Surveys in connection with Basin No. 5 have been continued. Property and seizure lines have been run out, and plans have been made in connection with changes in the roads. Early in the year plans and specifications were completed for the dam, and on July 17 a contract was awarded to Moulton O'Mahoney for building the dam for $454,729.90. Since that time the plans have been modified to harmonize with the work contemplated by the State for a metropolitan system. Owing to delays caused by negotiating with Southboro', in regard to changes in roads, no work has yet been done.

Early in January, 1893, some studies and surveys were made in connection with the proposed Natick Sewerage plans. In February a filter scheme for Pegan brook, Natick, was devised, which was carried out in June, and is now in successful operation. The water of the brook is pumped on to shallow beds, and is filtered before passing into the lake.

Studies have been continued during the year on many matters connected with the Sudbury supply, such as drainage of the swamps, and the possible construction of other basins.

Plans and specifications have been prepared for constructing filter beds on the brooks draining Marlborough.

Very truly yours,

(Signed) DESMOND FITZGERALD,

Resident Engineer.

HIGH-SERVICE PUMPING-STATIONS.

The engines and boilers at the Chesjnut Hill station are in good condition. The daily average quantity pumped was 15.4 per cent. more than in 1892. During the month of July Engine No. 1 pumped 10,451,500 gallons per day, and for the entire year the pumps delivered about 21 per cent. above their rated capacity.

The foundations for Engine No. 3 were completed in April. The engine is now being shipped from the works in New York and will soon be erected by the contractor. A contract was made on April 18 with the Atlantic Works to furnish a Belpaire fire-box boiler for use with the new engine. The table on page 145 shows in detail the work done by the pumping-engines and boilers during the year.

Engine No. 1 was run 4,512 hours, pumping	1,860,811,915 gallons.
Engine No. 2 was run 4,162½ hours, pumping	1,649,918,185 "
Total amount pumped	3,510,730,100 "
" " coal us ed	4,210,241 lbs.
Percentage, ashes and clinkers	7.6
Average lift in feet	126.71
Quantity pumped per lb. of coal	859.6 gallons.
Daily average amount pumped	9,618,400 "

On account of the large increase in the quantity pumped one boiler was not sufficient to easily supply steam for pumping, lighting, and heating the buildings, and a temporary boiler has been placed in the boiler-house for use in connection with the two old boilers.

COST OF PUMPING.

Salaries	$11,745.25
Fuel	9,159.58
Repairs	814.97
Oil, waste, and packing	593.37
Small supplies	88.13
Total	$22,401.30

Cost per million gallons raisek one foot high,	$0.05
Cost per million gallons pumped to reservoir,	$6.38

At the West Roxbury pumping-station the daily average quantity pumped was 96,900 gallons, an increase of 5.5 per cent. over the amount pumped in 1892.

At the East Boston station 402,400 gallons per day have been pumped for the supply of the high-service district, and 24,000 gallons per day for the Breed's island high service.

The pump used for the Breed's island service is in poor condition, and should be replaced by a new pump.

MYSTIC LAKE.

On January 1, 1893, the surface of the lake was 1.50 feet below high-water mark. During the month of January the water-surface gradually fell, and on February 7 was 4.15 feet below high water. Copious rain and melting snow quickly filled the lake, and from February 9 to June 7 water was wasted over the dam. During the summer and fall the lake surface fell, and on October 23 it was 8.90 feet below high water. The temporary pumps were used at the lake to raise the water into the conduit from October 19 to November 4.

During November and December the lake filled slowly, and on January 1, 1894, was 3.15 feet below high water.

Advantage was taken of the low water in the lake to remove about 14,000 cubic yards of loam from the section of the lake near the mouth of the Abbajona river, and depositing it in the shallow coves.

MYSTIC-VALLEY SEWER.

The quantity of sewage pumped and chemically treated during the year was 126,226,000 gallons, an average of 361,700 gallons per day.

The table on page 147 gives the monthly quantities of sewage pumped, aluminum used, coal burned, etc.

MYSTIC CONDUIT AND RESERVOIR.

The conduit has been cleaned and is now in good condition.

Recommendations made in previous reports in regard to repairs at conduit screen chamber and at reservoir have not been carried out and are now renewed.

MYSTIC PUMPING-STATION.

There has been a large increase during the past year in the quantity pumped, and it has been necessary to run all of the pumps at times to maintain the supply.

Engine No. 1 was used 1,070¾ hours pumping	223,963,200 gallons.
Engine No. 2 was used 4,323½ hours pumping	968,212,000 "

Engine No. 3 was used 8,358¾ hours pumping	2,882,304,000 gallons.
Total amount pumped	4,074,479,200 "
Total amount coal consumed	9,188,000 lbs.
Percentage, ashes and clinkers	10.5
Average lift in feet	149.36
Quantity pumped per lb. of coal	443.5 gallons.
Average duty of engines per 100 lbs. coal, no deductions	55,239,700 ft. lbs.
Daily average amount pumped	11,163,000 gallons.

Cost of Pumping.

Salaries	$10,968 70
Fuel	18,790 47
Repairs	3,608 28
Oil, waste, and packing	674 50
Small supplies	187 01
Total	$34,228 96
Cost per million gallons raised one foot high	$0.056
Cost per million gallons pumped to reservoir	$8 40

The table on page 146 shows in detail the work done by the engines during the year.

Engine No. 1, which was the first of the well-known type of Worthington compound duplex pumping-engine ever built, has been thoroughly overhauled and put in repair during the year.

The steam cylinders were rebored and the pistons fitted with St. John's packing. The United States metallic packing, which had been in use on the piston-rods for nineteen years, was after some small repairs replaced as good as new. New piston-rods were placed in the low-pressure cylinders, the steam-valves reset, and other repairs made, for details of which see report of Superintendent.

A 250-light dynamo and 18-horse power Armington and Sims engine have been placed in the engine-house.

On December 30 a contract was made with the Blake Manufacturing Company for an additional engine to be placed in this station.

It is to be built from designs of Mr. E. D. Leavitt, and is a compound beam and fly-wheel engine operating two differential plunger-pumps. The capacity of the pumps will be about 10,500,000 gallons per 24 hours. It is expected that this engine will be ready for service before the end of the present year.

CONSUMPTION.

The daily average consumption for the year was as follows:

Sudbury and Cochituate Works . .	47,453,200 gallons.
Mystic Works	10,742,500 "
Total combined supplies . .	58,195,700 "

an increase of 13.8 per cent. from that of the previous year.

The consumption during each month for the past seven years is given by the table on page 138.

The following table shows the consumption per capita for the past two years:

Consumption.

MONTH.	COCHITUATE. Consumption in Gallons per Capita.		MYSTIC. Consumption in Gallons per Capita.		COMBINED SUPPLIES. Consumption in Gallons per Capita.	
	1892.	1893.	1892.	1893.	1892.	1893.
January	86.4	123.7	80.4	111.5	85.1	120.9
February	91.3	117.6	84.0	103.7	89.7	114.5
March	89.9	111.4	80.8	91.9	87.9	107.0
April	86.9	104.1	73.9	76.9	84.0	98.1
May	86.5	99.0	74.2	76.7	83.7	94.0
June	96.8	100.4	81.6	81.5	93.4	96.1
July	106.3	110.6	85.8	80.6	101.7	104.0
August	104.5	108.3	77.9	77.6	98.5	101.5
September	104.8	105.5	76.2	71.8	98.4	98.0
October	103.1	104.2	74.3	75.7	96.6	97.8
November	95.4	99.3	73.3	75.0	90.4	93.9
December	100.7	106.9	82.9	90.9	96.7	103.3
Average	96.1	107.5	78.8	84.4	92.2	102.4

On June 29 a small section of the Charlestown district, containing a population of about 2,400, was connected with the Cochituate high service.

The consumption per capita was larger than in any year since the works were built.

Loss of Head.

In order to have a continuous record of the water pressures in the mains at different points throughout the city, six recording pressure gauges have been placed in fire-engine houses.

These, with four gauges previously established, furnish a record which is of great value in determining the necessity for larger mains, and in case of excessive draft upon the supply for fires or other causes the available pressure at all times is accurately recorded.

The table on page 144 gives the results shown by these gauges.

Distribution.

On the Cochituate works 15.96 miles of pipe were laid, and 10 miles purchased of the Jamaica Pond Aqueduct Company were connected with our system. About two miles of pipe have been abandoned, and the total now connected with the system is 560 miles.

No large mains have been laid during the year, and nothing has been done in the improvement of the supply for fire-service by the replacing of old mains with new ones of larger size.

Seventeen hundred feet of the 6-inch flexible pipe crossing the channel between Moon and Long islands has been relaid, it having been frozen and burst during the winter. Pipes have been laid from Long island to Rainsford island, 3,600 feet of 4-inch pipe on the islands, and 2,200 feet of 3-inch wrought-iron pipe across the channel.

The distribution system of the Mystic works has been extended 4.3 miles and 5.36 miles have been relaid, generally with pipe of larger size. The length of mains now connected with these works is 164.8 miles, of which 39.1 miles are maintained by the city of Boston, the remainder being under the control of other municipalities.

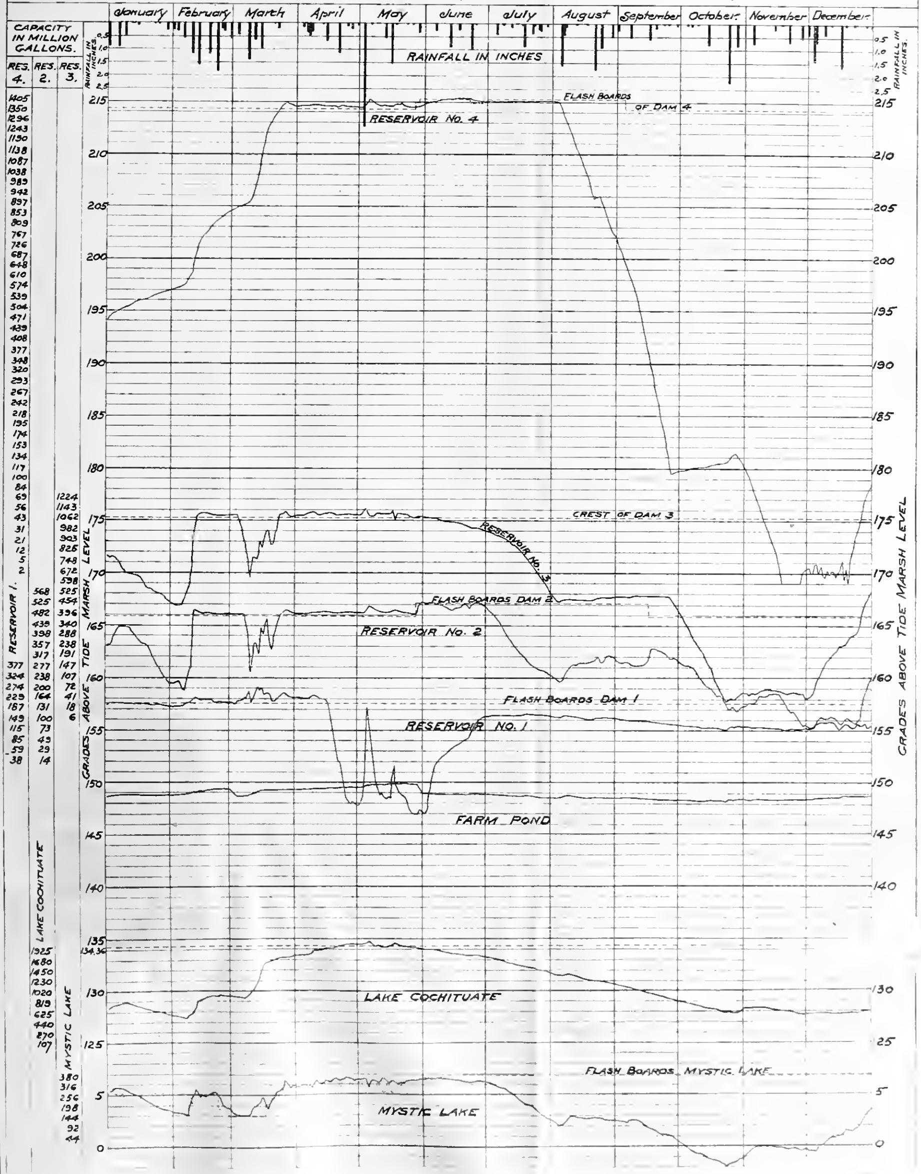
Two hundred and forty-nine hydrants have been established in the Cochituate and 83 in the Mystic works, making the total number now in use on the combined supplies 7,348.

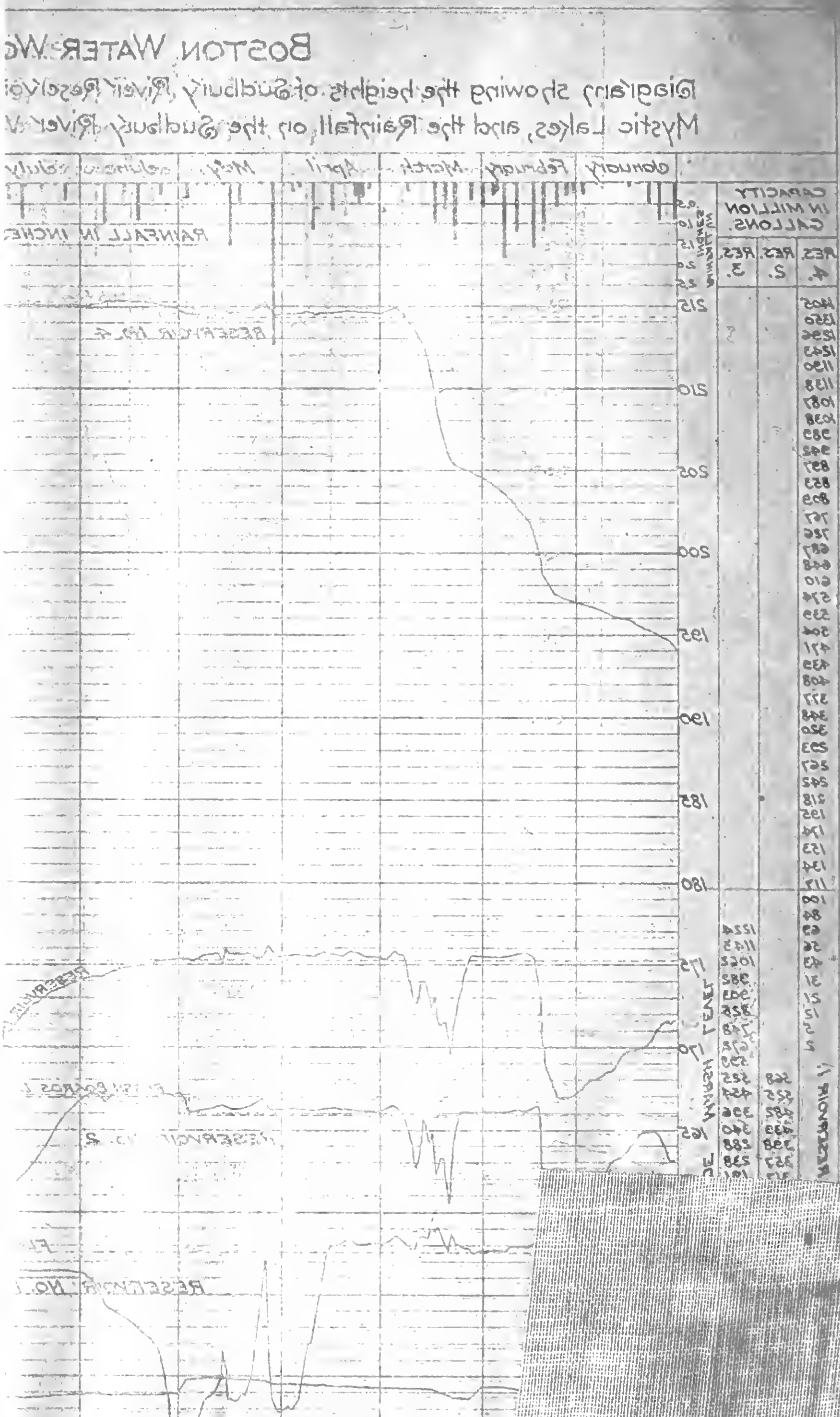
Contracts have been made for pipes for an additional 30-inch main in Dorchester avenue and D street from Swett street to Congress street for the improvement of the supply in South Boston, and for an additional main to reinforce the present supply for the Brighton district.

Pipes for an additional force main, 36 inches in diameter, between the Chestnut Hill Pumping-station and Fisher Hill reservoir, and for the extension of the 24-inch low service

BOSTON WATER WORKS.

Diagram showing the heights of Sudbury River Reservoirs, Farm Pond, and Cochituate and Mystic Lakes, and the Rainfall on the Sudbury River Water Shed during the year 1893.





main in Dorchester are on hand and the mains will be laid during the coming season.

Twenty-five contracts for rock excavation were made during the year. Two hundred and sixteen petitions for main pipe extensions were reported upon in regard to grade of street, size of main, and cost of laying.

The pipe laid during the year has been measured, the gates and hydrants located and plotted on the plans.

The records from the four pumping-stations, the lakes, reservoirs, the Mystic sewer, and the returns from the pipe foundries, etc., have been carefully recorded.

Appended to this report will be found the usual tables of rainfall, consumption, yield of water-sheds, etc.

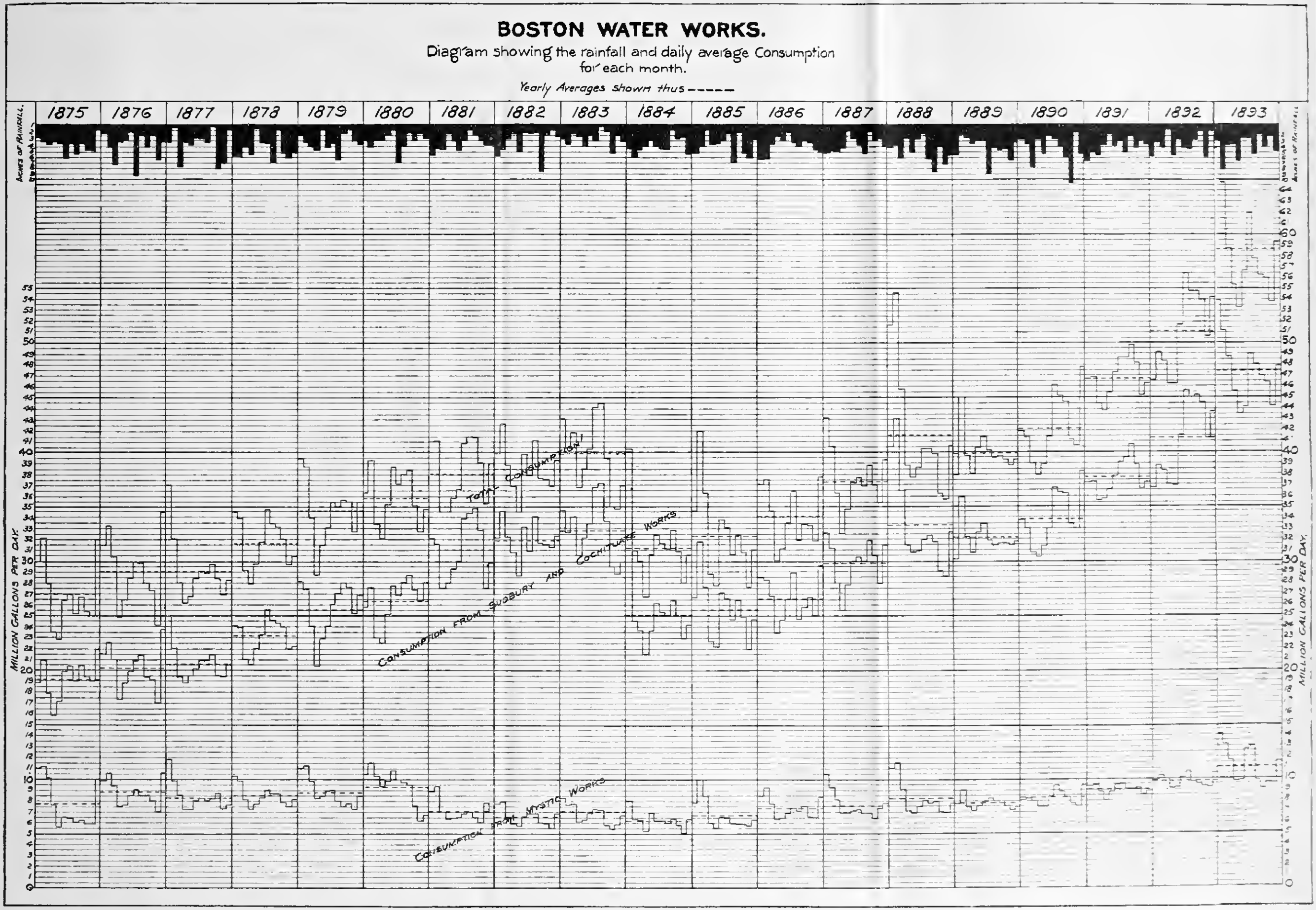
Respectfully submitted,

William Jackson,
City Engineer.

Daily Average Consumption of Water, in Gallons, from the Cochituate and Mystic Works.

Month.	Cochituate Works.							Mystic Works.						
	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1887.	1888.	1889.	1890.	1891.	1892.	1893.
January	32,687,600	40,485,700	30,172,000	33,680,000	37,230,100	36,756,400	53,847,100	10,488,600	11,107,100	7,769,500	8,187,900	9,389,300	9,878,200	14,129,700
February	31,224,300	43,105,000	35,855,200	33,030,700	37,280,700	38,881,500	51,299,400	9,346,700	11,620,900	9,073,600	8,299,700	9,466,900	10,332,200	13,174,700
March	28,124,100	36,463,400	32,180,000	30,844,400	35,533,400	38,395,100	48,700,200	8,175,000	9,242,000	7,537,600	8,055,800	8,811,000	9,970,500	11,692,700
April	25,591,500	31,473,800	30,814,500	30,446,600	35,751,600	37,171,000	45,573,100	6,933,800	7,276,700	7,185,700	7,481,600	8,045,800	9,145,000	9,812,500
May	27,925,000	30,802,000	32,719,500	31,381,200	36,580,700	37,055,900	43,451,500	6,916,300	6,932,300	7,663,600	7,488,400	8,841,300	9,204,900	9,817,400
June	30,069,000	31,026,100	33,377,900	33,022,700	37,801,900	41,564,000	44,125,100	7,159,800	7,615,200	8,017,700	8,396,000	9,478,400	10,146,300	[1]10,460,000
July	30,469,700	32,014,400	31,870,300	36,701,100	39,062,600	45,738,100	48,986,900	7,250,000	8,267,500	8,315,600	9,463,300	9,581,700	10,702,900	[1]10,167,000
August	30,063,100	32,432,700	31,403,200	36,316,000	39,460,400	45,631,600	48,062,000	6,871,900	7,859,100	8,113,200	8,932,200	9,122,300	9,751,500	9,826,200
September . . .	31,946,600	31,836,500	31,722,800	36,165,800	40,677,700	45,261,900	46,926,500	6,868,600	7,266,300	7,966,000	8,436,700	9,128,700	9,549,400	9,115,000
October	30,562,700	29,110,800	31,702,200	33,429,800	38,845,600	44,626,700	46,416,600	6,436,600	7,096,400	7,627,500	7,784,100	9,250,100	9,340,500	9,630,400
November . . .	28,062,000	28,590,900	31,532,400	32,955,100	36,640,800	41,347,800	44,328,900	7,361,200	6,990,800	7,316,700	7,601,300	8,585,200	9,230,000	9,569,700
December . . .	31,511,500	32,686,200	31,829,000	38,334,100	37,342,500	43,766,400	47,807,800	7,835,300	7,918,600	7,473,200	9,448,300	8,960,600	10,473,700	11,620,800
Yearly average .	29,852,100	33,310,700	32,070,000	33,871,700	37,686,900	41,312,400	47,453,200	7,620,000	8,258,400	7,830,500	8,301,400	9,055,200	9,810,800	10,742,500

[1] From June 7 to July 29 about 3,000,000 gallons per day were wasted from a blow-off.


BOSTON WATER WORKS.
Diagram showing the rainfall and daily average Consumption for each month.
Yearly Averages shown thus -----
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
INCHES OF RAINFALL.
MILLION GALLONS PER DAY.
TOTAL CONSUMPTION
CONSUMPTION FROM SUDBURY AND COCHITUATE WORKS
CONSUMPTION FROM MYSTIC WORKS

Division of Sudbury-River Water, 1885–1893.

MONTH.	1885.	1886.	1887.	1888.	1889.		1890.	1891.	1892.		1893.
	To Chestnut Hill Res'r.	To Chestnut Hill Res'r.	To Chestnut Hill Res'r.	To Chestnut Hill Res'r.	To Lake Cochituate.	To Chestnut Hill Res'r.	To Chestnut Hill Res'r.	To Chestnut Hill Res'r.	To Lake Cochituate.	To Chestnut Hill Res'r.	To Chestnut Hill Res'r.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
January	473,900,000	502,200,000	602,200,000	895,400,000	. . . . . .	484,500,000	518,600,000	715,900,000	. . . . . .	630,800,000	1,325,900,000
February . . .	560,400,000	380,800,000	472,000,000	906,700,000	. . . . . .	564,600,000	475,000,000	560,800,000	. . . . . .	610,400,000	957,600,000
March	495,900,000	467,400,000	456,700,000	691,400,000	. . . . . .	584,500,000	498,600,000	573,200,000	45,100,000	625,200,000	1,023,900,000
April	350,400,000	307,000,000	385,400,000	468,800,000	. . . . . .	490,500,000	417,000,000	641,900,000	545,000,000	662,500,000	917,000,000
May	308,500,000	344,700,000	444,200,000	566,300,000	233,400,000	615,700,000	536,300,000	740,300,000	114,700,000	690,490,000	858,600,000
June	768,000,000	427,100,000	463,600,000	489,000,000	. . . . . .	567,600,000	513,100,000	629,500,000	197,500,000	779,300,000	856,700,000
July	434,600,000	534,500,000	387,500,000	528,900,000	. . . . . .	534,000,000	664,100,000	755,100,000	. . . . . .	948,000,000	1,040,800,000
August	401,100,000	463,100,000	352,800,000	626,600,000	. . . . . .	443,700,000	625,500,000	722,900,000	. . . . . .	897,700,000	994,100,000
September . .	386,100,000	414,700,000	577,300,000	581,600,000	. . . . . .	475,500,000	606,400,000	732,400,000	. . . . . .	876,300,000	948,300,000
October	368,300,000	474,100,000	672,300,000	435,900,000	. . . . . .	414,100,000	539,900,000	715,300,000	. . . . . .	908,500,000	956,600,000
November . . .	297,600,000	381,800,000	607,100,000	410,900,000	. . . . . .	454,600,000	526,000,000	752,200,000	. . . . . .	788,000,000	862,700,000
December . . .	379,900,000	570,200,000	703,000,000	605,200,000	. . . . . .	501,200,000	675,500,000	767,100,000	. . . . . .	1,216,100,000	995,700,000
Totals	5,224,700,000	5,267,600,000	6,124,100,000	7,224,700,000	233,400,000	6,130,500,000	6,596,000,000	8,306,600,000	902,300,000	9,633,200,000	11,737,900,000
Tot'l div'rsion from Sudbury river.	5,224,700,000	5,267,600,000	6,124,100,000	7,224,700,000	6,363,900,000		6,596,000,000	8,306,600,000	10,535,500,000		11,737,900,000
Average daily diversion for whole year.	14,314,200	14,431,800	16,778,400	19,739,600	17,435,300		18,071,200	22,757,800	28,800,000		32,158,600

Statement showing Amount of Water drawn from Lake Cochituate; Amount wasted; Amount of Rainfall collected in Lake; Amount received into Lake from Sudbury River; Percentage of Rainfall collected, etc., 1852 to 1893; Water-shed of Lake, 12,077 Acres.

Year.	Amount of Water drawn from Lake.	Amount of Water wasted from Lake.	Amount received into Lake from Sudbury River.	Storage.		Total amount of Rainfall collected in Lake.	Daily average amount of Rainfall collected in Lake.	Rainfall.	Rainfall collected.	Percentage of Rainfall collected.
				Gain.	Loss.					
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Inches.*	*Inches.*	*Per cent.*
1852 [1]	2,974,042,800	4,020,566,900	....	....	261,360,000	6,733,249,700	18,396,900	47.93	20.61	43.
1853	3,117,939,500	3,166,417,500	....	239,580,000	....	6,523,937,000	17,873,800	55.73	19.51	35.
1854	3,614,230,000	4,187,733,000	....	....	217,800,000	7,584,163,000	20,778,500	43.15	22.87	53.
1855	3,776,399,500	No account kept	....	....	326,700,000	....	....	34.96	.....	......
1856	4,409,787,600	"	....	598,950,000	....	....	....	40.80	.....	......
1857	4,644,990,000	10,625,900,000	....	32,670,000	....	15,303,560,000	41,927,600	63.10	46.69	74.
1858	4,689,155,000	1,934,500,000	....	....	141,570,000	6,482,085,000	17,759,000	48.66	19.46	40.
1859 [2]	4,808,875,000	7,569,000,000	....	283,140,000	....	12,661,015,000	34,687,700	49.02	38.24	78.
1860	6,309,108,000	None.	....	174,240,000	....	6,483,348,000	17,714,100	55.44	19.40	35.
1861	6,639,095,900	3,377,559,000	....	....	1,459,260,000	8,557,394,900	23,444,900	45.44	25.45	56.
1862	6,059,000,000	33,200,000	....	1,306,800,000	....	7,399,000,000	20,271,200	49.69	22.36	45.
1863	5,927,052,500	2,165,696,500	....	762,300,000	....	8,855,049,000	24,260,400	69.30	26.88	39.
1864	6,105,306,700	1,368,746,000	....	....	1,848,577,000	5,625,475,700	15,370,200	42.60	18.35	43.
1865	4,621,630,000	1,688,120,700	....	743,242,500	....	7,052,993,200	19,323,300	49.46	20.50	41.
1866	4,463,585,000	None.	....	743,242,500	....	5,206,827,500	14,265,300	62.32	16.01	26.
1867	4,951,225,000	2,482,041,000	....	....	698,811,000	6,734,455,000	18,450,600	56.25	21.80	39.
1868	5,405,515,000	2,507,684,000	....	346,371,000	....	8,259,570,000	22,567,200	49.71	24.98	50.
1869	5,503,751,000	1,635,570,000	....	480,882,000	....	7,620,203,000	20,877,300	64.34	21.99	34.
1870	5,477,810,000	4,818,971,000	....	....	1,736,085,000	8,560,696,000	23,453,900	55.89	26.08	47

1871	5,223,500,000	None.			250,933,000	4,972,567,000	13,623,500	45.39	15.16	33.
1872	5,775,151,200	None.	1,676,666,400	1,543,995,500		5,642,480,300	15,416,600	48.47	17.22	35.
1873	6,511,826,900	2,917,977,000			515,132,000	8,914,671,900	24,423,800	45.43	27.13	60.
1874	6,623,972,900	1,145,851,700			1,367,715,000	6,402,109,600	17,540,000	35.93	19.52	54.
1875	7,092,955,500	None.	2,555,800,000	1,222,885,000		5,760,040,500	15,780,900	45.49	17.57	39.
1876	7,277,175,200	1,619,243,800	2,528,300,000	43,438,000		6,411,557,000	17,517,900	48.49	19.54	40.
1877	7,626,889,200	1,484,978,600	1,894,350,000	378,727,000		7,596,244,800	20,811,600	43.80	23.17	53.
1878	7,743,904,700	3,341,875,000	2,668,300,000	219,789,000		8,637,268,700	23,663,700	53.58	26.34	49.
1879	6,051,838,900	1,523,361,400	411,300,000		1,322,697,300	5,841,203,000	16,003,300	38.01	17.81	47.
1880	4,284,147,100	65,577,700	826,700,000		146,265,000	3,376,759,800	9,226,100	35.83	10.30	29.
1881	2,846,459,700	2,231,016,700	187,600,000	468,089,400		5,357,965,800	14,679,400	41.09	16.34	40.
1882	3,935,490,600	1,358,543,700			357,334,700	4,936,699,600	13,525,200	40.29	15.05	37.
1883	4,731,227,700	162,361,800	1,245,100,000		334,400,000	3,314,089,500	9,079,700	31.20	10.11	32.
1884	4,533,156,450	1,842,837,100	1,416,300,000	1,340,436,700		6,300,130,250	17,213,450	45.57	19.21	42.
1885	4,091,674,900	1,006,622,800		8,594,800		5,106,892,500	13,991,500	43.66	15.57	36.
1886	4,432,536,100	3,116,283,200			360,662,000	7,188,157,300	19,693,600	46.97	21.92	47.
1887	4,802,120,700	3,658,652,900			763,205,000	7,697,568,600	21,089,200	41.58	23.47	56.
1888	4,968,503,100	4,229,200,000		959,309,000		10,157,012,100	27,751,400	56.93	30.97	54.
1889	5,570,423,600	3,373,929,000	233,400,000	454,766,800		9,165,719,400	25,111,600	50.23	27.95	56.
1890	5,722,170,800	2,380,441,200			64,166,300	8,038,445,700	22,023,100	51.23	24.51	48.
1891	5,508,178,900	6,064,000,000			1,056,057,800	10,516,121,100	28,811,300	46.42	32.07	69.
1892	5,464,791,300	281,000,000	902,300,000	200,284,300		5,033,775,600	13,753,500	39.04	15.35	39.
1893	5,623,532,500	255,300,000			89,200,000	5,789,632,500	15,862,000	45.28	17.65	39.
Averages	5,236,669,700	2,341,019,000				7,195,003,400	19,700,400	47.71	21.88	45.3

[1] Observations of rainfall at Lake Cochituate commenced 1852, and these observations are assumed as correct for the whole district.
[2] Lake raised two feet.

Statement showing Amount of Water drawn from Mystic Lake; Amount wasted; Amount of Rainfall collected in Lake; Percentage of Rainfall collected, etc., 1876 to 1893; Water-shed of Lake, 17,200 Acres.

Year.	Amount of Water drawn from Lake.	Amount of Water wasted from Lake.	Storage.		Total amount of Rainfall collected in Lake.	Daily average amount of Rainfall collected in Lake.	Rainfall.	Rainfall collected.	Percentage of Rainfall collected.
			Gain.	Loss.					
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Inches.*	*Inches.*	*Per cent.*
1876	3,230,101,300	6,369,774,700	. . . .	32,583,000	9,567,293,000	26,140,100	47.00	20.49	43.6
1877	3,069,554,800	7,250,223,500	. . . .	16,291,400	10,303,486,900	28,228,700	43.095	22.06	51.2
1878	3,367,490,400	8,718,547,600	. . . .	26,000,000	12,060,038,000	33,041,200	54.065	25.82	47.8
1879	3,490,848,200	4,625,691,800	. . . .	203,000,000	7,913,540,000	21,680,900	35.30	16.94	48.0
1880	3,692,195,700	2,158,761,200	. . . .	113,500,000	5,703,756,900	15,584,000	34.42	12.21	35.5
1881	2,815,579,900	5,534,300,000	371,200,000	. . . .	8,721,079,900	23,893,400	41.91	18.67	44.5
1882	2,570,896,700	4,444,668,000	15,000,000	. . . .	7,030,564,700	19,261,800	39.165	15.05	38.4
1883	2,664,514,200	2,034,702,600	. . . .	347,579,000	4,351,637,800	11,922,300	31.22	9.32	29.84
1884	2,469,761,000	6,574,003,800	380,600,000	. . . .	9,424,364,800	25,749,600	44.39	20.18	45.46
1885	2,639,278,800	5,558,860,500	. . . .	33,200,000	8,194,939,300	22,451,900	44.50	17.55	39.43
1886	2,862,947,500	7,743,258,900	. . . .	28,400,000	10,577,806,400	28,980,300	45.56	22.65	49.71
1887	2,954,257,500	7,414,213,000	. . . .	11,000,000	10,357,470,500	28,376,600	46.42	22.17	47.77
1888	3,205,121,100	11,334,593,100	. . . .	6,000,000	14,533,714,200	39,709,600	56.745	31.12	54.84
1889	3,007,539,800	8,879,787,500	12,000,000	. . . .	11,899,327,300	32,600,900	50.395	25.48	50.56
1890	3,212,284,500	8,953,727,900	. . . .	3,000,000	12,163,012,400	33,323,300	49.37	26.04	52.75
1891	3,500,817,500	10,027,714,400	. . . .	171,000,000	13,357,531,900	36,600,000	47.40	28.60	60.34
1892	3,811,766,200	3,474,213,200	177,000,000	. . . .	7,462,979,400	20,390,700	39.115	15.98	40.85
1893	4,331,743,200	4,958,528,500	. . . .	95,000,000	9,195,271,700	25,192,500	44.20	19.69	44.54
Average	3,160,927,700	6,449,198,300	. . . .	. . . .	9,600,989,700	26,284,700	44.13	20.56	45.84

Statement showing Amount of Water diverted from Sudbury River to Lake Cochituate and Chestnut Hill Reservoir; Amount wasted; Amount of Flow in River; Percentage of Rainfall collected, etc., 1875 to 1893.

(Water-shed from 1875 to 1878, inclusive, = 77.764 sq. miles; in 1879 and 1880 = 78.238 sq. miles; and from 1881 to 1893, inclusive, = 75.2 sq. miles.)

YEAR.	Amount of Water diverted to Lake Cochituate and Chestnut Hill Reservoir.	Amount of Water used by Framingham Water Co.	Amount of Water wasted from River.	STORAGE.		Total amount of flow in River.	Daily average amount of flow in River.	Rainfall.	Rainfall collected.	Percentage of Rainfall collected.
				Gain.	Loss.					
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Inches.*	*Inches.*	*Per cent.*
1875	2,555,800,000	. . . .	24,971,600,000	66,300,000	. . . .	27,593,700,000	75,599,200	45.490	20.418	44.88
1876	2,528,300,000	. . . .	29,942,300,000	. . . .	160,700,000	32,309,900,000	88,278,400	49.563	23.908	48.24
1877	1,894,350,000	. . . .	32,438,300,000	112,100,000	. . . .	34,444,750,000	94,369,200	44.018	25.487	57.90
1878	3,422,100,000	. . . .	37,125,200,000	654,700,000	. . . .	41,202,000,000	112,882,200	57.931	30.487	52.63
1879	3,749,200,000	. . . .	20,817,500,000	962,200,000	. . . .	25,528,900,000	69,942,200	41.419	18.775	45.33
1880	6,230,200,000	. . . .	11,290,000,000	. . . . . .	958,600,000	16,561,600,000	42,250,300	38.177	12.182	31.91
1881	8,845,300,000	. . . .	17,279,000,000	751,700,000	. . . .	26,876,000,000	73,633,900	44.169	20.565	46.56
1882	7,735,200,000	. . . .	16,273,900,000	. . . .	352,600,000	23,656,600,000	64,812,300	39.394	18.102	45.95
1883	8,455,000,000	. . . .	7,251,900,000	. . . .	1,086,400,000	14,620,500,000	40,056,200	32.780	11.188	34.13
1884	6,110,600,000	. . . .	23,228,900,000	1,744,600,000	. . . .	31,084,100,000	84,929,200	47.135	23.784	50.46
1885	5,224,700,000	61,800,000	19,878,800,000	. . . .	446,900,000	24,718,400,000	67,721,600	43.545	18.916	43.44
1886	5,266,600,000	76,600,000	23,023,000,000	1,464,500,000	. . . .	29,831,700,000	81,730,700	46.065	22.825	49.55
1887	6,124,100,000	87,500,000	25,334,500,000	117,400,000	. . . .	31,663,500,000	86,749,300	42.705	24.227	56.73
1888	7,224,700,000	61,500,000	39,040,500,000	390,600,000	. . . .	46,717,300,006	127,642,900	57.465	35.749	62.21
1889	6,363,900,000	59,500,000	31,550,400,000	. . . .	2,800,000	37,971,000,000	104,030,100	49.95	29.056	58.17
1890	6,596,000,000	74,500,000	28,667,100,000	. . . .	57,400,000	35,280,200,000	96,658,100	53.00	26.998	50.94
1891	8,306,600,000	80,500,000	28,799,600,000	. . . .	1,100,800,000	36,085,900,000	98,865,500	49.52	27.612	55.76
1892	10,535,500,000	82,800,000	11,143,000,000	. . . .	257,700,000	21,503,600,000	58,753,000	41.83	16.456	39.34
1893	11,737,900,000	103,000,000	17,405,500,000	. . . .	789,800,000	28,456,600,000	77,963,300	48.225	21.774	45.15
Averages .	6,258,265,800	76,400,000	23,445,200,000	. . . .	. . . .	29,794,913,200	81,413,700	45.915	22.553	48.38

Average Maximum and Minimum Monthly and Yearly Heights in Feet above Tide Marsh Level to which Water would rise at different Stations on the Boston Water-Works.

1893.	Boston Common.		Engine-house No. 8, Salem street.		Engine-house No. 7, East street.		Engine-house No. 38, Congress street, South Boston.		Engine-house No. 2, Fourth street, South Boston.		Engine-house No. 9, Paris street, East Boston.		Engine-house No. 16, River street, Dorchester.		Engine-house No. 32, Bunker Hill street, Charlestown, Mystic Supply.		710 Albany street.		City Hall. High Service.		Average Height of Water in Brookline Reservoir.
Month.	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	
Jan. . . .	106.66	92.75	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	110.16	97.77	. . .	. . .	122.81
Feb. . . .	113.80	98.89	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	111.75	97.32	. . .	. . .	122.92
March . .	115.65	98.90	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	115.09	101.29	. . .	. . .	123.18
April . . .	119.31	102.02	. . .	. . .	118.46	98.76	. . .	. . .	119.25	93.62	113.80	80.40	118.53	94.23	. . .	. . .	118.01	102.21	. . .	. . .	123.58
May . . .	119.53	99.53	. . .	. . .	119.36	94.76	. . .	. . .	119.10	90.58	115.29	82.03	118.54	92.70	. . .	. . .	118.64	98.82	227.42	210.21	123.56
June . . .	120.15	102.16	119.40	98.20	119.92	99.85	117.07	96.00	119.77	92.13	116.23	82.33	119.53	94.83	. . .	. . .	119.33	102.00	226.63	206.37	123.57
July . . .	119.74	101.16	118.96	96.90	119.62	99.93	117.46	94.67	119.35	92.84	115.03	80.06	118.93	94.77	139.55	117.22	119.00	100.18	221.19	205.66	123.57
August . .	119.11	101.81	118.13	98.60	119.28	102.50	117.33	95.72	118.53	93.33	114.51	81.45	118.12	96.45	144.19	127.22	118.16	101.79	222.13	207.73	123.49
Sept. . . .	118.75	101.43	118.13	98.03	119.22	101.29	117.62	94.48	118.76	93.43	114.50	80.66	118.34	95.10	144.90	127.90	118.33	101.35	221.46	207.23	123.39
Oct. . . .	118.83	102.02	118.93	98.51	119.74	102.00	117.33	95.72	119.74	95.16	115.77	81.64	119.26	97.80	143.32	126.87	119.27	102.45	218.80	204.72	123.55
Nov. . . .	120.00	104.28	119.60	101.76	120.20	104.66	118.82	100.46	121.65	100.69	117.03	86.96	120.00	101.58	144.23	128 70	119.93	105.60	223.73	208.08	123.58
Dec. . . .	116.35	101.44	116.22	99.29	116.55	102.21	114.68	96.71	116.94	96.55	108.88	82.20	116.72	100.00	140.93	126.42	117.27	102.55	221.96	203.54	123.43
	118.80	102.02	118.33	98.67	119.10	102.09	117.20	96.29	119.17	95.33	114.30	82.16	118.56	97.61	142.86	125.72	118.66	102.32	221.54	206.16	123.39

Statement of Operations at the Chestnut Hill Pumping-Station for 1893.

1893.	Engine No. 1.			Engine No. 2.			Total amount pumped. 2% allowed for slip.	Daily average amount pumped.	Total amount of coal consumed.	Daily average amount of coal consumed.	Total ashes and clinkers.	Per cent. ashes and clinkers.	Quantity pumped per lb. of coal. No correction for heating and lighting.	Quantity pumped per lb. of coal. Corrected for heating and lighting.	Average lift in feet.	Division of Coal.			Duty in ft.-lbs. per 100 lbs. of coal.		Water evaporated in boilers per lb. of coal.	
	Total pumping-time.		Amount pumped.	Total pumping-time.		Amount pumped.										Heating.	Lighting.	Pumping.	Without correction for heating and lighting.	Corrected for heating and lighting.	Actual.	From and at 212° F., including feed-water heater.
Month.	*Hrs.*	*Min.*	*Gallons.*	*Hrs.*	*Min.*	*Gallons.*	*Gallons.*	*Gallons.*	*Lbs.*	*Lbs.*	*Lbs.*	*Per cent.*	*Gals.*	*Gals.*	*Feet.*	*Lbs.*	*Lbs.*	*Lbs.*	*Ft.-lbs.*	*Ft.-lbs.*	*Lbs.*	*Lbs.*
Jan. . . .	721	15	299,926,500	. .	.	. . . . . .	299,926,500	9,675,000	370,656	11,957	31,423	8.5	809.2	933.6	127.89	19,728	29,675	321,253	86,307,100	99,579,600	10.08	11.93
Feb. . . .	. .	.	. . . . . .	656	10	257,962,750	257,962,750	9,213,000	330,315	11,797	20,684	6.3	780.9	876.2	127.38	16,167	19,721	294,427	82,965,200	93,077,900	10.05	11.89
March . .	741	15	284,959,675	. .	.	. . . . . .	284,959,675	9,192,200	369,321	11,914	24,039	6.5	771.6	857.9	126.87	18,593	18,563	332,165	81,640,300	90,772,500	9.02	10.65
April . .	. .	.	. . . . . .	717	45	258,125,000	258,125,000	8,604,200	312,547	10,418	22,844	7.3	825.9	915.3	126.31	14,374	16,154	282,019	86,999,900	96,417,400	9.73	11.47
May . . .	600	35	233,168,000	138	00	52,023,250	285,191,250	9,199,700	331,376	10,690	28,532	8.6	860.6	918.1	127.36	5,912	14,833	310,631	91,414,300	97,519,300	9.79	11.44
June . . .	. .	.	. . . . . .	717	30	284,099,750	284,099,750	9,470,000	326,315	10,877	27,040	8.3	870 6	906.7	127.59	. . .	12,975	313,340	92,643,800	96,479,900	9.67	11.24
July . . .	741	00	323,997,025	. .	.	. . . . . .	323,997,025	10,451,500	359,901	11,610	29,241	8.1	900.2	935.7	127.98	. . .	13,654	346,247	96,087,400	99,876,500	9.82	11.36
August .	. .	.	. . . . . .	742	10	306,027,100	306,027,100	9,871,800	347,181	11,199	26,631	7.7	881.5	922.4	128.02	. . .	15,425	331,756	94,112,600	98,488,400	10.04	11.62
Sept. . .	695	30	295,473,475	. .	.	. . . . . .	295,473,475	9,849,100	349,588	11,653	27,424	7.8	845.2	889.9	128.10	. . .	17,550	332,038	90,297,800	95,070,500	10.33	11.98
Oct. . . .	171	40	70,778,465	578	25	245,082,460	315,860,925	10,189,100	376,155	12,134	27,509	7.3	839.7	891.6	123.35	1,899	19,979	354,277	86,384,200	91,718,800	9.81	11.45
Nov. . .	99	30	41,727,750	612	30	246,597,875	288,325,625	9,610,900	356,144	11,871	27,408	7.7	809.6	883.8	124.88	8,422	21,504	326,218	84,317,300	92,052,200	10.46	12.32
Dec. . . .	741	15	310,781,025	. .	.	. . . . . .	310,781,025	10,025,200	380,742	12,282	28,500	7.5	816.3	897.9	124.81	11,506	23,100	346,136	84,964,800	93,459,400	10.19	12.04
Totals and averages,	4512	00	1,860,811,915	4162	30	1,649,918,185	3,510,730,100	9,618,400	4,210,241	11,535	321,275	7.6	834.3	902.4	126.71	96,601	223,133	3,890,507	88,118,600	95,360,400	9.92	11.63

Statement of Operations at the Mystic Pumping-Station for 1893.

1893.	Engine No. 1.			Engine No. 2.			Engine No. 3.			Total amount pumped.	Daily average amount pumped.	Daily average amount of coal consumed.	Daily average amount of ashes and clinkers.	Per cent. ashes and clinkers.	Quantity pumped per pound of coal.	Average lift in feet.	Duty in foot-pounds per 100 pounds of total coal.
	Total pumping-time.		Amount pumped.	Total pumping-time.		Amount pumped.	Total pumping-time.		Amount pumped.								
Month.	*Hrs.*	*Min.*	*Gallons.*	*Hrs.*	*Min.*	*Gallons.*	*Hrs.*	*Min.*	*Gallons.*	*Gallons.*	*Gallons.*	*Lbs.*	*Lbs.*	*Per ct.*	*Gals.*	*Feet.*	*Foot-pounds.*
January	155	15	30,532,200	715	30	161,177,400	737	00	246,860,800	438,570,400	14,147,400	31,806	3,305	10.4	444.8	150.72	55,911,300
February	31	30	6,553,400	595	5	132,215,600	672	00	229,760,000	368,529,000	13,161,800	30,036	2,927	9.7	438.2	149.71	54,713,300
March	36	30	8,184,200	324	45	114,110,700	710	30	239,641,600	361,936,500	11,675,400	26,065	2,457	9.4	447.9	148.09	55,323,800
April	. . .	. . .	. . . .	201	00	42,808,500	717	15	252,467,200	295,275,700	9,842,500	20,933	1,789	8.5	470.2	147.51	57,843,700
May	. . .	. . .	. . . .	216	30	41,993,100	737	45	261,939,200	303,932,300	9,804,300	20,200	1,847	9.1	485.5	147.	59,652,700
June	. . .	. . .	. . . .	650	30	134,374,900	701	30	245,350,400	[1] 379,725,300	[1] 12,657,500	28,167	2,822	10.0	.4	148.59	55,688,900
July	. . .	. . .	. . . .	686	30	148,538,700	740	00	253,926,400	[1] 402,465,100	[1] 12,982,700	30,100	3,453	11.5	431.4	149.92	53,935,200
August	78	15	17,893,500	140	30	26,274,000	728	00	260,300,800	304,468,300	9,821,600	21,710	2,451	11.3	452.4	149.58	56,437,300
September . . .	130	15	28,433,300	20	00	4,363,900	698	45	239,667,200	272,464,400	9,082,100	20,800	2,365	11.4	436.6	14 85	54,569,300
October	349	15	73,778,600	316	15	66,243,700	475	00	158,796,800	298,819,100	9,639,300	23,516	2,721	11.6	409.9	150.7	51,545,500
November . . .	131	15	25,639,800	77	45	16,172,100	715	15	246,092,800	287,904,700	9,596,800	21,983	2,529	11.5	436.6	149.97	54,601,500
December . . .	158	30	32,948,200	379	00	79,939,400	725	45	247,500,800	360,388,400	11,625,400	26,952	3,068	11.4	431.3	150.26	54,054,700
Totals and averages	1,070	45	223,963,200	4,323	30	968,212,000	8,358	45	2,882,304,000	4,074,479,200	11,163,000	25,172	2,645	10.5	443.5	149.36	55,239,700

[1] From June 7 to July 29 about 3,000,000 gallons per day were wasted at a blow-off. The daily average consumption is given on p. 125.

Table showing Work done at Mystic Sewage Pumping-Station during the Year 1893.

1893.	Pumping-time.		Amount of sewage pumped and treated.	Sulphate al. used.	Coal used.	Daily average amount of sewage pumped and treated.
	Hrs.	*Min.*	*Gallons.*	*Lbs.*	*Lbs.*	*Gallons.*
January	517	15	12,135,000	31,210	40,250	391,500
February	485	00	12,336,000	29,610	37,470	440,600
March	582	40	16,371,000	36,030	43,680	528,100
April	502	50	11,573,000	29,300	39,980	413,300
May	517	15	11,746,000	31,395	43,150	405,000
June	517	45	10,244,000	27,800	41,960	341,500
July	501	45	8,966,000	24,050	39,060	298,900
August	[1] 409	00	7,224,000	18,845	32,320	314,100
September	468	35	8,212,000	20,495	33,000	283,200
October	485	40	8,493,000	23,155	31,920	274,000
November	459	55	8,490,000	[2] 14,220	36,800	292,800
December	532	15	10,436,000	23,025	40,374	347,900
Totals	5,979	55	126,226,000	309,135	459,964	361,700

[1] August 20th to 27th repairing engine.
[2] November 5th to 14th no sulphate of alumina used. Supply-pipe being repaired.

Statement of Operations at the West Roxbury Pumping-Station for the Year 1893.

1893.	Total pumping-time.		Total amount pumped.	Daily average amount pumped.	Quantity pumped per lb. of coal.	Total amount of coal consumed.	Per cent. of ashes and clinkers.	Average lift.
Month.	*Hours.*	*Min.*	*Gallons.*	*Gallons.*	*Gallons.*	*Pounds.*	*Per cent.*	*Feet.*
January . .	218	00	3,265,950	105,400	136.2	23,975	19.7	135.85
February .	195	00	3,002,550	107,200	142.0	21,150	19.3	134.15
March . . .	170	00	2,401,875	77,500	134.4	17,875	19.5	133.50
April . . .	139	00	1,931,700	64,400	135.8	14,225	18.7	134.23
May	175	00	2,502,675	80,700	153.3	16,325	19.1	137.05
June . . .	214	00	3,049,425	101,600	158.0	19,300	20.6	137.34
July	310	00	4,150,950	133,900	159.0	26,100	21.4	138.45
August . .	290	00	3,830,775	123,600	162.0	23,650	20.8	138.72
September .	242	30	2,994,825	99,800	158.7	18,875	20.2	138.52
October . .	257	00	3,132,450	101,100	159.0	19,700	20.1	139.05
November .	225	00	2,562,975	85,400	148.1	17,300	20.6	139.40
December .	217	00	2,531,700	81,700	134.1	18,875	20.7	138.02
Totals and averages,	2,652	30	35,357,850	96,900	149.0	237,350	20.1	137.02

Statement of Operations at the East Boston Pumping-Station for the Year 1893.

1893.	Engines Nos. 1 and 2.				Engine No. 3.				Total amount of coal consumed.	Per cent of ashes and clinkers.
	Total pumping-time.		Total amount pumped to reservoir.	Daily average.	Total pumping-time.		Total amount pumped to tank.	Daily average.		
Month.	*Hrs.*	*M.*	*Gallons.*	*Gallons*	*Hrs.*	*M.*	*Gallons.*	*Gallons*	*Pounds.*	*Per ct.*
Jan. .	437	55	19,280,100	621,900	61	50	967,020	31,200	57,910	19.8
Feb. .	348	15	14,774,620	527,600	54	10	828,900	29,600	43,520	20.4
March,	343	45	13,588,120	438,300	40	05	625,380	20,200	40,260	20.0
April .	290	30	10,978,940	366,000	36	20	541,140	18,000	30,310	19.5
May .	274	15	10,727,220	346,000	40	40	582,180	18,800	29,910	18.5
June .	266	40	10,777,060	359,200	50	20	722,760	24,100	30,130	18.5
July .	277	15	11,656,260	376,000	67	00	944,700	30,500	31,827	18.5
Aug. .	272	35	11,260,420	363,200	57	35	795,180	25,600	30,030	18.6
Sept. .	264	00	10,986,640	366,200	48	15	685,680	22,900	27,260	18.5
Oct. .	264	45	11,043,060	356,200	50	25	690,660	22,300	26,760	18.1
Nov. .	239	15	9,903,460	330,100	45	35	625,080	20,800	25,070	18.3
Dec. .	284	15	11,894,260	383,700	54	05	761,340	24,600	31,520	17.7
Totals,	3,563	25	146,870,160	402,400	606	20	8,770,020	24,000	404,507	19.0

Rainfall in Inches and Hundredths on the Sudbury River Water-shed for the Year 1893.

1893.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	0.930	0.295	...	...	...	...	...	...	0.270	...	...	0.370
2	...	...	...	...	...	...	...	...	...	...	...	...
3	...	0.335	...	...	3.950	...	...	...	...	...	...	...
4	...	...	0.415	0.130	...	...	...	...	...	0.060	...	1.430
5	...	...	...	...	...	...	0.425	1.615	...	...	0.755	0.680
6	0.935	0.590	...	0.360	0.050	0.275	...	0.430	...	0.095	...	...
7	...	...	...	0.520	...	...	...	0.115	0.515	...	...	...
8	...	...	...	0.340	...	...	0.040	...	...	...	...	...
9	0.490	...	1.390	...	...	...	...	...	...	0.005	...	0.410
10	...	1.170	...	...	...	...	...	...	...	...	...	...
11	...	...	...	...	...	...	...	...	...	...	...	...
12	0.015	...	0.625	...	...	...	0.145	0.035	...	...	...	0.020
13	0.010	1.610	...	0.025	0.505	0.880	...	...	...	...	...	...
14	...	...	...	...	...	...	...	...	...	0.790	...	...
15	0.120	...	0.980	0.670	...	...	...	...	...	...	0.185	...
16	...	...	...	...	1.570	...	...	...	0.625	...	...	...
17	...	...	...	...	...	0.230	0.060	0.030	...	...	...	1.640
18	...	1.190	...	...	0.055	...	0.865	...	...	...	0.005	...
19	...	0.055	...	...	...	...	...	...	0.175	...	...	0.040
20	...	...	...	...	...	...	...	...	...	...	...	...
21	...	...	0.040	1.140	...	...	...	1.770	...	...	...	...
22	...	1.840	...	...	...	...	0.385	...	...	...	0.695	...
23	0.040	...	0.220	...	0.050	0.985	0.065	...	0.035	...	...	0.065
24	...	0.205	...	...	...	...	...	0.925	...	2.260	...	...
25	0.085	0.310	...	0.120	...	0.010	0.205	...	0.035	...	...	...
26	...	...	...	...	0.065	...	0.275	...	...	...	...	...
27	...	...	...	0.210	...	...	...	...	...	...	...	...
28	...	0.595	...	...	0.365	...	...	...	...	0.855	0.555	...
29	0.280	...	...	...	...	...	0.095	0.495	0.080	...	...	0.055
30	...	...	...	0.090	...	...	...	...	...	...	...	..
31	0.020	...	...	...	...	...	0.010	...	...	...	...	0.150
Totals	2.925	8.195	3.670	3.605	6.610	2.380	2.570	5.415	1.735	4.065	2.195	4.860

Total rainfall during the year, 48.225 inches, being an average of two gauges, located at Framingham and Ashland.

Rainfall in Inches and Hundredths at Lake Cochituate for the Year 1893.

1893.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	0.79	0.26	...	...	2.94	...	...	...	0.29	...	...	0.33
2	...	...	...	...	...	...	...	...	...	...	...	...
3	...	0.32	...	...	...	0.02	...	...	...	...	...	...
4	...	...	0.16	0.09	...	...	...	...	...	0.07	0.68	1.41
5	...	...	...	...	...	...	0.34	1.59	...	...	...	0.90
6	0.86	0.57	...	0.23	...	0.23	...	1.55	...	0.06	...	...
7	...	...	...	...	...	...	...	0.08	0.49	...	...	...
8	...	...	...	0.82	...	...	0.04	..	...	...	...	...
9	0.51	...	1.21	...	...	...	...	...	...	...	...	0.38
10	...	0.98	...	...	...	...	...	...	...	...	...	...
11	...	...	...	...	...	...	...	...	...	...	...	...
12	...	...	0.53	...	...	...	0.10	0.03	...	...	...	0.04
13	0.02	1.33	...	0.01	0.44	0.83	...	...	...	...	...	...
14	...	...	...	...	...	...	...	...	...	0.98	...	...
15	0.08	...	0.99	0.65	...	...	...	...	...	...	0.18	...
16	...	...	...	...	1.29	...	...	...	0.54	...	...	1.66
17	...	...	...	...	0.11	0.29	0.01	...	...	...	...	...
18	...	0.88	...	...	...	...	1.21	0 03	...	...	...	...
19	...	...	...	...	...	...	...	...	0.25	...	...	0.05
20	...	0.24	...	...	...	...	...	...	...	...	...	...
21	...	...	0.04	1.06	...	...	...	1.54	...	...	...	...
22	...	1.57	...	...	...	...	0.31	...	0.01	...	0.69	...
23	...	...	0.20	...	0.04	1.38	0.10	...	0.02	...	...	0.06
24	0.09	0.37	...	...	...	...	...	0.58	..	1.86	...	...
25	...	0.29	...	0.12	...	...	0.13	...	0.06	...	...	...
26	...	...	...	...	...	...	0.08	...	...	...	...	...
27	...	...	...	0.17	0.62	...	...	...	...	...	...	...
28	...	0.45	...	...	...	...	...	...	...	0.77	0.53	...
29	0.24	...	...	...	...	...	0.08	0.46	0.10	...	...	0.07
30	...	...	...	0.06	0.01	...	...	...	...	...	...	...
31	0.02	...	...	...	...	...	...	...	...	...	...	0.13
Totals .	2.61	7.26	3.13	3.21	5.45	2.75	2.40	5.86	1.76	3.74	2.08	5.03

Total rainfall during the year, 45.28 inches.

Rainfall in Inches and Hundredths at Mystic Lake for the Year 1893.

1893.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	0.99	0.23	...	...	...	...	...	...	0.37	...	...	0.44
2	...	...	...	...	...	...	...	...	...	...	...	...
3	...	0.35	...	...	...	0.07	...	...	...	...	...	...
4	...	...	0.13	0.04	3.68	...	...	...	...	0.10	...	1.42
5	...	...	...	...	...	...	0.22	1.63	...	...	0.70	...
6	0.30	0.52	...	0.19	0.04	0.20	..	1.21	...	0.05	...	0.33
7	...	...	...	0.53	...	...	...	0.19	0.68	...	...	...
8	...	...	...	0.24	...	...	0.03	...	...	...	...	...
9	0.50	...	1.05	...	...	...	...	...	...	...	...	...
10	...	0.85	...	...	...	...	...	...	...	...	...	0.37
11	...	...	...	...	...	...	...	...	...	...	...	...
12	...	...	0.27	...	...	...	0.06	0.03	...	...	...	0.06
13	...	1.27	...	0.01	0.48	0.28	...	...	...	...	0.03	...
14	...	...	...	0.45	...	...	...	...	...	1.20	...	...
15	0.08	...	0.89	0.33	...	...	...	...	0.02	0.05	0.18	...
16	...	...	...	...	1.60	...	...	...	0.52	...	...	...
17	...	...	...	...	...	0.28	...	...	0.03	...	...	1.36
18	...	1.40	...	...	0.05	...	0.36	0.18	...	...	...	...
19	...	0.20	...	...	...	...	0.18	...	0.14	...	...	0.07
20	...	...	...	...	...	...	...	0.04	...	...	0.03	...
21	...	...	0.03	1.20	...	...	...	1.50	...	...	...	...
22	...	1.75	...	0.02	...	...	0.94	...	0.03	...	0.86	...
23	0.02	...	0.17	...	0.03	1.27	0.07	...	0.05	...	...	0.11
24	...	0.29	...	...	...	...	...	0.25	...	2.25	...	...
25	0.07	0.30	...	0.15	...	...	0.14	...	0.06	...	...	...
26	...	...	...	...	0.03	...	0.02	...	...	...	...	...
27	...	...	...	0.19	0.35	...	...	...	...	...	...	...
28	...	0.34	...	...	...	...	...	...	...	0.45	0.45	...
29	0.27	...	...	...	...	...	0.02	0.38	0.11	...	...	0.10
30	...	...	0.01	0.02	...	...	...	...	...	...	...	...
31	0.03	...	...	...	...	...	...	...	...	...	...	0.09
Totals	2.26	7.50	2.55	3.37	6.26	2.10	2.04	5.41	2.01	4.10	2.25	4.35

Total rainfall during the year, 44.20 inches.

Rainfall Received and Collected, 1893.

MONTH.	SUDBURY.			COCHITUATE.			MYSTIC.		
	Rainfall.	Rainfall collected.	Per cent. collected.	Rainfall.	Rainfall collected.	Per cent. collected.	Rainfall.	Rainfall collected.	Per cent. collected.
	Inches.	Inches.	Per cent.	Inches.	Inches.	Per cent.	Inches.	Inches.	Per cent.
January . .	2.925	0.773	26.44	2.61	0.64	24.53	2.26	0.752	33.27
February .	8.195	2.485	30.32	7.26	2.55	35.14	7.50	2.143	28.58
March . . .	3.670	5.789	157.74	3.13	4.12	131.74	2.55	4.521	177.31
April . . .	3.605	3.668	101.75	3.21	2.42	75.65	3.37	2.718	80.66
May	6.610	5.143	77.81	5.45	1.83	33.52	6.26	4.420	70.61
June . . .	2.380	0.759	31.88	2.75	0.75	27.22	2.10	1.040	49.52
July	2.570	0.282	10.96	2.40	0.38	15.85	2.04	0.473	23.17
August . .	5.415	0.322	5.95	5.86	0.77	13.16	5.41	0.684	12.64
September .	1.735	0.187	10.75	1.76	0.42	23.93	2.01	0.411	20.45
October . .	4.065	0.395	9.72	3.74	1.09	28.78	4.10	0.551	13.43
November .	2.195	0.550	25.07	2.08	1.00	48.36	2.25	0.709	31.53
December .	4.860	1.421	29.23	5.03	1.68	33.42	4.35	1.265	29.07
Totals and averages,	48.225	21.774	45.15	45.28	17.65	38.99	44.20	19.687	44.54

Monthly Rainfall in Inches, during 1893, at Various Places in Eastern Massachusetts.

Place.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Framingham	2.93	8.15	3.68	3.39	6.94	2.47	2.91	5.38	1.80	4.08	2.23	4.94	48.90
Dam 4, Ashland	2.92	8.24	3.66	3.82	6.28	2.29	2.23	5.45	1.67	4.05	2.16	4.78	47.55
Lake Cochituate	2.61	7.26	3.13	3.21	5.45	2.75	2.40	5.86	1.76	3.74	2.08	5.03	45.28
Chestnut Hill	2.74	8.31	3.15	3.32	5.77	2.33	2.10	6.53	1.85	3.70	2.00	4.91	46.71
Mystic Lake	2.26	7.50	2.55	3.37	6.26	2.10	2.04	5.41	2.01	4.10	2.25	4.35	44.20
Mystic Pumping-station	1.97	7.71	2.54	3.42	6.10	2.07	2.07	5.36	1.92	4.11	2.21	4.21	43.69
Boston Pipe-yard	2.08	7.06	2.50	2.93	5.42	2.64	1.74	7.01	1.54	3.50	2.38	4.83	43.63
Cambridge Observatory	2.03	7.28	3.71	2.66	5.06	1.62	2.05	5.20	1.35	3.46	1.79	4.79	41.00
Waltham, Boston Manufacturing Co.	2.31	7.65	2.99	2.94	5.06	2.06	2.46	8.40	1.62	4.13	2.21	5.22	47.05
Lowell, Locks and Canals Co.	2.39	7.71	2.44	2.95	6.66	2.42	2.76	3.94	2.29	3.82	1.93	5.46	44.77
Average of ten places	2.424	7.687	3.035	3.201	5.900	2.275	2.276	5.854	1.781	3.869	2.124	4.852	45.278

Table showing the Temperature of Air and Water at Various Stations on the Water-Works.

1893.	Temperature of Air.						Temperature of Water.	
	Chestnut Hill Reservoir.			Framingham.			Brookline Reservoir.	Mystic Engine-House.
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Mean.	Mean.
January	54.0	-7.0	18.8	52.0	-11.0	16.5	37.0	34.4
February	49.5	-2.0	26.0	50.0	-4.0	24.5	36.3	35.0
March	54.5	7.0	32.9	55.0	3.0	31.3	35.9	34.6
April	69.0	19.0	44.6	71.0	16.0	43.8	43.7	42.3
May	90.5	36.0	57.7	89.0	31.0	56.8	54.9	54.4
June	93.0	44.0	67.3	93.0	42.0	66.5	66.7	67.6
July	93.5	50.0	71.7	93.0	49.0	70.0	72.3	72.1
August	94.0	49.5	70.4	93.0	46.0	69.3	72.3	72.9
September	84.5	40.0	59.2	79.0	36.0	57.8	66.2	66.4
October	80.0	27.5	54.2	77.0	24.0	52.6	58.0	57.8
November	68.0	12.0	40.6	64.0	9.0	38.8	43.7	48.3
December	54.0	-7.0	29.0	54.0	-8.0	27.2	37.0	36.4

SUMMARY OF STATISTICS.

REPORT FOR 1893.

Boston Water-Works, Suffolk County, Massachusetts, supplies also the cities of Somerville, Chelsea, and Everett.

Population by census of 1890:

Boston	448,477
Chelsea	27,909
Somerville	40,152
Everett	11,068
Total	527,606

Date of construction:

Cochituate Works	1848
Mystic "	1864

By whom owned. — City of Boston.

Sources of supply. — Lake Cochituate, Sudbury river, and Mystic lake.

Mode of supply. — Sixty-five per cent. from gravity works.
Thirty-five " " pumping "

PUMPING.

	COCHITUATE.	MYSTIC.
Builder of pumping machinery	Holly Co.	H. R. Worthington.
Description of coal used:		
a Kind	Bituminous.	Bituminous.
c Size	Broken.	Broken.
e Price per gross ton, in bins	$5.30, $5.00, $4.75	$4.45, $4.35, $4.12, $4.20, $4.36
f Per cent. of ash,	7.6	10.5

	COCHITUATE.	MYSTIC.
Coal consumed for year, in lbs.	4,210,241	9,188,000
Total pumpage for year, in gallons	3,510,730,100	4,074,479,200
Average dynamic head, in feet	126.71	149.36
Gallons pumped per lb. of coal	834.3	443.5
Duty in foot-lbs. per 100 lbs. of coal	88,118,600	55,239,700
Cost of pumping figured on pumping-station expenses, viz.:	$22,401.30	$34,228.96

	COCHITUATE.	MYSTIC.
Cost per million gallons raised to reservoir .	$6.38	$8.40
Cost per million gallons raised one foot high .	$0.05	$0.056

CONSUMPTION.

Estimated population .	441,400	127,300
Estimated No. of consumers,	435,000	126,000
Total consumption, gallons,	17,320,427,300	3,921,019,200
Passed through meters .	4,252,830,000	701,372,910
Percentage metered . .	24.5	17.9
Average daily consumption, gallons	47,453,200	10,742,500
Gallons per day, each inhabitant . . .	107.4	84.4
Gallons per day, each consumer	109.1	85.3
Gallons per day to each tap,	712.6	479.6

DISTRIBUTION.

Mains.

	COCHITUATE.	MYSTIC.
Kind of pipe used,	Cast-Iron.	Cast-Iron, Wrought-Iron, and Cement.
Sizes	48 in. to 4 in.	30 in. to 3 in.
Extended, miles . .	17	4.3
Total now in use . .	560.04	164.8
Distribution-pipes less than 4-in., length, miles	2.11	5.5
Hydrants added . .	189	83
Hydrants now in use .	6,042	1,306
Stop-gates added . .	296	138
Stop-gates now in use .	6,206	1,937

Services.

Kind of pipe used,	Lead.	Lead and Wrought-Iron.
Sizes	$\frac{5}{8}$ in. to 6 in.	$\frac{1}{2}$ in. to 4 in.
Extended, feet . .	37,881	23,100
Service-taps added .	1,512	810
Total now in use . .	66,586	22,398
Meters added . .	134	26
Meters now in use .	4,046	461
Motors and elevators in use	539	21

CIVIL ORGANIZATION OF THE WATER-WORKS, FROM THEIR COMMENCEMENT TO FEBRUARY 1, 1894.

Water Commissioners.

Nathan Hale,‡ James F. Baldwin,‡ Thomas B. Curtis. From May 4, 1846, to January 4, 1850.

Engineers for Construction.

John B. Jervis, of New York, Consulting Engineer. From May, 1846, to November, 1848.‡

E. S. Chesbrough, Chief Engineer of the Western Division. From May, 1846, to January 4, 1850.‡

William S. Whitwell, Chief Engineer of the Eastern Division. From May, 1846, to January 4, 1850.

Engineers having Charge of the Works.

E. S. Chesbrough, Engineer. From November 18, 1850, to October 1, 1855.‡

George H. Bailey, Assistant Engineer. From January 27, 1851, to July 19, 1852.

H. S. McKean, Assistant Engineer. From July 19, 1852, to October 1, 1855.‡

James Slade, Engineer. From October 1, 1855, to April 1, 1863.‡

N. Henry Crafts, Assistant Engineer. From October 1, 1855, to April 1, 1863.

N. Henry Crafts, City Engineer. From April 1, 1863, to November 25, 1872.

Thomas W. Davis, Assistant Engineer. From April 1, 1863, to December 8, 1866.‡

Henry M. Wightman, Resident Engineer at C. H. Reservoir. From February 14, 1866, to November, 1870.‡

A. Fteley, Resident Engineer on construction of Sudbury-river works. From May 10, 1873, to April 7, 1880.

Joseph P. Davis, City Engineer. From November 25, 1872, to March 20, 1880.

Henry M. Wightman, City Engineer. From April 5, 1880, to April 3, 1885.‡

William Jackson, City Engineer. From April 21, 1885, to present time.

Desmond FitzGerald, Resident Engineer on Additional Supply. From February 20, 1889, to present time.

After January 4, 1850, Messrs. E. S. Chesbrough, W. S. Whitwell, and J. Avery Richards were elected a Water Board, subject to the direction of a Joint Standing Committee of the City Council, by an ordinance passed December 31, 1849, which was limited to keep in force one year; and in 1851 the Cochituate Water Board was established.

Cochituate Water Board.

Presidents of the Board.

Thomas Wetmore, elected in 1851, and resigned April 7, 1856‡ . . . . Five years.

JOHN H. WILKINS, elected in 1856, and resigned June 5, 1860‡	Four years.
EBENEZER JOHNSON, elected in 1860, term expired April 3, 1865‡	Five years.
OTIS NORCROSS, elected in 1865, and resigned January 15, 1867‡	One year and nine months.
JOHN H. THORNDIKE, elected in 1867, term expired April 6, 1868‡	One year and three months.
NATHANIEL J. BRADLEE, elected April 6, 1868, and resigned January 4, 1871‡	Two years and nine months.
CHARLES H. ALLEN, elected January 4, 1871, to May 4, 1873	Two years and four months.
JOHN A. HAVEN, elected May 4, 1873, to Dec. 17, 1874‡	One year and seven months.
THOMAS GOGIN, elected December 17, 1874, and resigned May 31, 1875.	Six months.
L. MILES STANDISH, elected August 5, 1875, to July 31, 1876‡	One year.

Members of the Board.

THOMAS WETMORE, 1851, 52, 53, 54, and 55‡	Five years.
JOHN H. WILKINS, 1851, 52, 53, *56, 57, 58, and 59‡	Eight years.
HENRY B. ROGERS, 1851, 52, 53, *54, and 55‡	Five years.
JONATHAN PRESTON, 1851, 52, 53, and 56‡	Four years.
JAMES W. SEAVER, 1851‡	One year.
SAMUEL A. ELIOT, 1851.‡	
JOHN T. HEARD, 1851‡	One year.
ADAM W. THAXTER, Jr., 1852, 53, 54, and 55‡	Four years.
SAMPSON REED, 1852 and 1853‡	Two years.
EZRA LINCOLN, 1852‡	One year.
THOMAS SPRAGUE, 1853, 54, and 55‡	Three years.
SAMUEL HATCH, 1854, 55, 56, 57, 58, and 61‡	Six years.
CHARLES STODDARD, 1854, 55, 56, and 57‡	Four years.
WILLIAM WASHBURN, 1854 and 55‡	Two years.
TISDALE DRAKE, 1856, 57, 58, and 59‡	Four years.
THOMAS P. RICH, 1856, 57, and 58‡	Three years.
JOHN T. DINGLEY, 1856 and 59‡	Two years.
JOSEPH SMITH, 1856‡	Two months.
EBENEZER JOHNSON, 1857, 58, 59, 60, 61, 62, 63, and 64‡	Eight years.
SAMUEL HALL, 1857, 58, 59, 60, and 61‡	Five years.
GEORGE P. FRENCH, 1859, 60, 61, 62, and 63‡	Five years.
EBENEZER ATKINS, 1859‡	One year.
GEORGE DENNIE, 1860, 61, 62, 63, 64, and 65	Six years.
CLEMENT WILLIS, 1860‡	One year.
G. E. PIERCE, 1860‡	One year.
JABEZ FREDERICK, 1861, 62, and 63‡	Three years.
GEORGE HINMAN, 1862 and 63	Two years.
JOHN F. PRAY, 1862‡	One year.
J. C. J. BROWN, 1862	One year.
JONAS FITCH, 1864, 65, and 66‡	Three years.
OTIS NORCROSS, *1865 and 66‡	Two years.
JOHN H. THORNDIKE, 1864, 65, 66, and 67‡	Four years.
BENJAMIN F. STEVENS, 1866, 67, and 68	Three years.
WILLIAM S. HILLS, 1867	One year.
CHARLES R. TRAIN, 1868‡	One year.
JOSEPH M. WIGHTMAN, 1868 and 69‡	Two years.
BENJAMIN JAMES, *1858, 68, and 69	Three years.
FRANCIS A. OSBORN, 1869	One year.
WALTER E. HAWES, 1870‡	One year.

John O. Poor, 1870	One year.
Hollis R. Gray, 1870	One year.
Nathaniel J. Bradlee, 1863, 64, 65, 66, 67, 68, 69, 70, and 71‡	Nine years.
George Lewis, 1868, 69, 70, and 71‡	Four years.
Sidney Squires, 1871‡	One year.
Charles H. Hersey, 1872	One year.
Charles H. Allen, 1869, 70, 71, and 72 . . .	Four years.
Alexander Wadsworth, *1864, 65, 66, 67, 68, 69, and 72	Seven years.
Charles R. McLean, 1867, 73, and 74‡ . . .	Three years.
Edward P. Wilbur, 1873 and 74	Two years.
John A. Haven, 1870, 71, 72, 73, and 74‡ . . .	Five years.
Thomas Gogin, 1873, 74, and 75*	Three years.
Amos L. Noyes, 1871, 72, and 75	Three years.
William G. Thacher, 1873, 74, and 75‡ . . .	Three years.
Charles J. Prescott, 1875	One year.
Edward A. White, 1872, 73, 74, 75, and 76† ‡ . .	Five years.
Leonard R. Cutter, 1871, 72, 73, 74, 75, and 76† .	Six years.
L. Miles Standish, 1860, 61, 63, 64, 65, 66, 67, 74, 75, and 76† ‡	Ten years.
Charles E. Powers, *1875 and 1876† ‡ . . .	Two years.
Solomon B. Stebbins, 1876†	One year.
Nahum M. Morrison, 1876†	One year.
Augustus Parker, 1876†	One year.

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*Mr. John H. Wilkins resigned November 15, 1855, and Charles Stoddard was elected to fill the vacancy. Mr. Henry B. Rogers resigned October 22, 1865. Mr. Wilkins was reëlected February, 1856, and chosen President of the Board, which office he held until his resignation, June 5, 1860, when Mr. Ebenezer Johnson was elected President; and July 2 Mr. L. Miles Standish was elected to fill the vacancy occasioned by the resignation of Mr. Wilkins. Otis Norcross resigned January 15, 1867, having been elected Mayor of the city. Benjamin James served one year, in 1858, and was reëlected in 1868. Alexander Wadsworth served six years, 1864–69, and was reëlected in 1872. Thomas Gogin resigned May 31, 1875. Charles E. Powers was elected July 15, to fill the vacancy occasioned by the resignation of Mr. Gogin.

† Served until the organization of the Boston Water Board.

‡ Deceased.

BOSTON WATER BOARD,

Organized July 31, 1876.

TIMOTHY T. SAWYER, from July 31, 1876, to May 5, 1879; and from May 1, 1882, to May 4, 1883.
LEONARD R. CUTTER, from July 31, 1876, to May 4, 1883.
ALBERT STANWOOD, from July 31, 1876, to May 7, 1883.
FRANCIS THOMPSON, from May 5, 1879, to May 1, 1882.‡
WILLIAM A. SIMMONS, from May 7, 1883, to August 18, 1885.
GEORGE M. HOBBS, from May 4, 1883, to May 4, 1885.
JOHN G. BLAKE, from May 4, 1883, to August 18, 1885.
WILLIAM B. SMART, from May 4, 1885, to March 18, 1889.
HORACE T. ROCKWELL, from August 25, 1885, to April 25, 1888.
PHILIP J. DOHERTY, from March 18, 1889, to May 4, 1891.
THOMAS F. DOHERTY, from August 26, 1885, to May 5, 1890; and from May 4, 1891, to present time.
ROBERT GRANT, from April 25, 1888, to July 18, 1893.
JOHN W. LEIGHTON, from May 5, 1890, to present time.
WILLIAM S. MCNARY, from August 15, 1893, to present time.

ORGANIZATION OF THE BOARD FOR YEAR 1893.

Chairman.

ROBERT GRANT, to July 18, 1893.

THOS. F. DOHERTY, from August 15, 1893.

Secretary and Chief Clerk.

WALTER E. SWAN.

City Engineer and Engineer of the Board.

WILLIAM JACKSON.

Superintendent of the Eastern Division of Cochituate Department.

WILLIAM J. WELCH.

Superintendent of the Western Division and Resident Engineer of Additional Supply.

DESMOND FITZGERALD.

Superintendent of Mystic Division.

EUGENE S. SULLIVAN.

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‡ Deceased.

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